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Section 2: Solid State Lasers

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- 2.2 Glass Lasers
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Section 2.1

CRYSTALLINE PARAMAGNETIC ION LASERS

Introduction to the Tables

Crystalline paramagnetic ion lasers have used lanthanide and other transition group ions as the active ion. The operative transitions and general wavelengths for these laser ions are given in [Tables 2.1.1](#) and [2.1.2](#). Although the exact wavelength varies slightly with the crystal host and temperature, these tables can generally be used to identify the transitions involved in laser action.

A few ion-crystal systems in which only gain has been reported are listed in [Table 2.1.3](#).

Crystalline lasers based on transition metal and lanthanide ions are arranged in order of increasing wavelength in [Table 2.1.4](#). Lasers that have been tuned over a range of wavelengths are listed in order of the lowest lasing wavelength reported; the tuning range given is that for the configuration and conditions used and may not represent the extremes possible. A range of wavelengths in brackets denotes a number of discrete lines. The lasing ion is given in the second column and the host crystal in the third column. If codopants or sensitizing ions are added to the host, they are listed following the colon. The operating temperature and reference(s) are given in the final two columns.

A range of wavelengths is also listed if the host consists of mixed elements or a corresponding range of temperatures is given. In such cases the references should be consulted to determine the wavelengths for the specific compositions and temperatures used.

Further Reading

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Table 2.1.1
Transition Metal Ion Laser Transitions in Solids

Wavelength* (μm)	Ion	Transition
0.66–1.18	Ti ³⁺	$^2\text{E} \rightarrow ^2\text{T}_2$
0.68–0.70	Cr ³⁺	$^2\text{E} \rightarrow ^4\text{A}_2$
0.74–0.89	Cr ³⁺	$^4\text{T}_2 \rightarrow ^4\text{A}_2$
1.05–1.33	V ²⁺	$^4\text{T}_2 \rightarrow ^4\text{A}_2$
1.17–1.18	Mn ⁵⁺	$^1\text{E} \rightarrow ^3\text{A}_2$
1.17–1.63	Cr ⁴⁺	$^3\text{T}_2 \rightarrow ^3\text{A}_2$
1.31–1.94	Ni ²⁺	$^3\text{T}_2 \rightarrow ^3\text{A}_2$
1.62–2.50	Co ²⁺	$^4\text{T}_2 \rightarrow ^4\text{T}_1$
2.2–2.9	Cr ²⁺	$^5\text{E} \rightarrow ^5\text{T}_2$
3.5	Fe ²⁺	$^5\text{T}_2 \rightarrow ^5\text{E}$

* Wavelengths of transitions are only approximate; exact wavelengths and ranges are depend on the host and temperature.

Table 2.1.2
Lanthanide and Actinide Laser Ion Transitions in Solids

Wavelength* (μm)	Ion	Transition
0.17	Nd ³⁺	5d $\rightarrow$ ⁴ I _{11/2}
0.30	Ce ³⁺	5d $\rightarrow$ ² F _{5/2}
0.32	Ce ³⁺	5d $\rightarrow$ ² F _{7/2}
0.35	Tm ³⁺	¹ I ₆ $\rightarrow$ ³ H ₅
0.38	Nd ³⁺	⁴ D _{3/2} $\rightarrow$ ⁴ I _{11/2}
0.41	Nd ³⁺	² P _{3/2} $\rightarrow$ ⁴ I _{11/2}
0.45	Tm ³⁺	¹ D ₂ $\rightarrow$ ³ F ₄
0.46	Tm ³⁺	¹ I ₆ $\rightarrow$ ³ H ₄
0.46	Pr ³⁺	³ P ₁ $\rightarrow$ ³ H ₄
0.47	Er ³⁺	² P _{3/2} $\rightarrow$ ⁴ I _{11/2}
0.48	Tm ³⁺	¹ G ₄ $\rightarrow$ ³ H ₆
0.49	Pr ³⁺	³ P ₀ $\rightarrow$ ³ H ₄
0.51	Tm ³⁺	¹ D ₂ $\rightarrow$ ³ H ₅
0.53	Pr ³⁺	³ P ₁ $\rightarrow$ ³ H ₅
0.54	Pr ³⁺	³ P ₀ $\rightarrow$ ³ H ₅
0.54	Tb ³⁺	⁵ D ₄ $\rightarrow$ ⁷ F ₅
0.55	Er ³⁺	⁴ S _{3/2} $\rightarrow$ ⁴ I _{15/2}
0.55	Ho ³⁺	⁵ S ₂ $\rightarrow$ ⁵ I ₈
0.56	Er ³⁺	² H _{9/2} $\rightarrow$ ⁴ I _{13/2}
0.59	Sm ³⁺	⁴ G _{5/2} $\rightarrow$ ⁶ H _{7/2}
0.60	Pr ³⁺	³ P ₀ $\rightarrow$ ³ H ₆
0.61	Eu ³⁺	⁵ D ₀ $\rightarrow$ ⁷ F ₂
0.62	Er ³⁺	⁴ G _{11/2} $\rightarrow$ ⁴ I _{11/2}
0.62	Er ³⁺	² P _{3/2} $\rightarrow$ ⁴ F _{9/2}
0.63	Pr ³⁺	³ P ₂ $\rightarrow$ ³ F ₄
0.64	Pr ³⁺	³ P ₀ $\rightarrow$ ³ F ₂
0.65	Sm ³⁺	⁴ G _{5/2} $\rightarrow$ ⁶ H _{7/2}
0.65	Tm ³⁺	¹ G ₄ $\rightarrow$ ³ F ₄
0.67	Er ³⁺	⁴ F _{9/2} $\rightarrow$ ⁴ I _{15/2}
0.70	Pr ³⁺	³ P ₀ $\rightarrow$ ³ F ₃

Table 2.1.2—continued
Lanthanide and Actinide Laser Transitions in Solids

Wavelength* (μm)	Ion	Transition
0.70	Er^{3+}	$^2\text{H}_{9/2} \rightarrow ^4\text{I}_{11/2}$
0.70	Sm^{2+}	$5\text{d}, ^5\text{D}_0 \rightarrow ^7\text{F}_1$
0.72	Pr^{3+}	$^3\text{P}_0 \rightarrow ^3\text{F}_4$
0.73	Nd^{3+}	$^2\text{P}_{3/2} \rightarrow ^4\text{F}_{5/2}$
0.75	Ho^{3+}	$^5\text{S}_2 \rightarrow ^5\text{I}_7$
0.80	Tm^{3+}	$^3\text{H}_4 \rightarrow ^3\text{H}_6$
0.80	Tm^{3+}	$^1\text{G}_4 \rightarrow ^3\text{H}_5$
0.85	Er^{3+}	$^4\text{S}_{3/2} \rightarrow ^4\text{I}_{13/2}$
0.88	Pr^{3+}	$^3\text{P}_1 \rightarrow ^1\text{G}_4$
0.91	Pr^{3+}	$^3\text{P}_0 \rightarrow ^1\text{G}_4$
0.93	Nd^{3+}	$^4\text{F}_{3/2} \rightarrow ^4\text{I}_{9/2}$
0.93	Pm^{3+}	$^5\text{F}_1 \rightarrow ^5\text{I}_5$
0.98	Ho^{3+}	$^5\text{F}_5 \rightarrow ^5\text{I}_7$
0.99	Er^{3+}	$^4\text{I}_{11/2} \rightarrow ^4\text{I}_{15/2}$
0.99	Pr^{3+}	$^1\text{D}_2 \rightarrow ^3\text{F}_3$
1.01	Ho^{3+}	$^5\text{S}_2 \rightarrow ^5\text{I}_6$
1.03	Yb^{3+}	$^2\text{F}_{5/2} \rightarrow ^2\text{F}_{7/2}$
1.04	Pr^{3+}	$^1\text{G}_4 \rightarrow ^3\text{H}_4$
1.05	Pr^{3+}	$^1\text{D}_2 \rightarrow ^3\text{F}_4$
1.06	Nd^{3+}	$^4\text{F}_{3/2} \rightarrow ^4\text{I}_{11/2}$
1.1	Pm^{3+}	$^5\text{F}_1 \rightarrow ^5\text{I}_6$
1.2	Ho^{3+}	$^5\text{I}_6 \rightarrow ^5\text{I}_8$
1.26	Er^{3+}	$^4\text{S}_{3/2} \rightarrow ^4\text{I}_{11/2}$
1.26	Er^{3+}	$^4\text{F}_{9/2} \rightarrow ^4\text{I}_{13/2}$
1.3	Dy^{3+}	$^6\text{H}_{9/2} \rightarrow ^6\text{H}_{15/2}$
1.34	Pr^{3+}	$^1\text{G}_4 \rightarrow ^3\text{H}_5$
1.35	Nd^{3+}	$^4\text{F}_{3/2} \rightarrow ^4\text{I}_{13/2}$
1.40	Ho^{3+}	$^5\text{S}_2, ^5\text{F}_4 \rightarrow ^5\text{I}_5$
1.48	Tm^{3+}	$^3\text{H}_4 \rightarrow ^3\text{F}_4$
1.49	Ho^{3+}	$^5\text{F}_5 \rightarrow ^5\text{I}_6$

Table 2.1.2—continued
Lanthanide and Actinide Laser Transitions in Solids

Wavelength* (μm)	Ion	Transition
1.56	Er^{3+}	$4\text{I}_{13/2} \rightarrow 4\text{I}_{15/2}$
1.58	Tm^{3+}	$1\text{G}_4 \rightarrow 3\text{F}_3$
1.61	Pr^{3+}	$3\text{F}_3 \rightarrow 3\text{H}_4$
1.66	Er^{3+}	$2\text{H}_{11/2} \rightarrow 4\text{I}_{9/2}$
1.67	Er^{3+}	$4\text{S}_{3/2} \rightarrow 4\text{I}_{9/2}$
1.68	Er^{3+}	$4\text{I}_{9/2} \rightarrow 4\text{I}_{13/2}$
1.7	Ho^{3+}	$5\text{I}_5 \rightarrow 5\text{I}_7$
1.8	Nd^{3+}	$4\text{F}_{3/2} \rightarrow 4\text{I}_{15/2}$
1.9	Tm^{3+}	$3\text{F}_4 \rightarrow 3\text{H}_6$
2.0	Er^{3+}	$4\text{F}_{9/2} \rightarrow 4\text{I}_{11/2}$
2.0	Tm^{3+}	$1\text{G}_4 \rightarrow 3\text{F}_2$
2.1	Ho^{3+}	$5\text{I}_7 \rightarrow 5\text{I}_8$
2.3	Ho^{3+}	$5\text{F}_5 \rightarrow 5\text{I}_5$
2.3	Tm^{3+}	$3\text{H}_4 \rightarrow 3\text{H}_5$
2.35–2.83	U^{3+}	$4\text{I}_{11/2} \rightarrow 4\text{I}_{9/2}$
2.4	Dy^{2+}	$5\text{I}_7 \rightarrow 5\text{I}_8$
2.8	Er^{3+}	$4\text{I}_{11/2} \rightarrow 4\text{I}_{13/2}$
2.9	Ho^{3+}	$5\text{I}_6 \rightarrow 5\text{I}_7$
3.0	Dy^{3+}	$6\text{H}_{11/2} \rightarrow 6\text{H}_{15/2}$
3.4	Ho^{3+}	$5\text{S}_2 \rightarrow 5\text{F}_5$
3.5	Er^{3+}	$4\text{F}_{9/2} \rightarrow 4\text{I}_{9/2}$
3.6	Pr^{3+}	$1\text{G}_4 \rightarrow 3\text{F}_4$
3.9	Ho^{3+}	$5\text{I}_5 \rightarrow 5\text{I}_6$
4.3	Dy^{3+}	$6\text{H}_{11/2} \rightarrow 6\text{H}_{13/2}$
4.8	Er^{3+}	$4\text{I}_{9/2} \rightarrow 4\text{I}_{11/2}$
5.1	Nd^{3+}	$4\text{I}_{13/2} \rightarrow 4\text{I}_{11/2}$
5.2	Pr^{3+}	$3\text{F}_3 \rightarrow 3\text{H}_6$
7.2	Pr^{3+}	$3\text{F}_3 \rightarrow 3\text{F}_2$

*Wavelengths of transitions are only approximate; exact wavelengths are dependent on the host and temperature and the specific Stark levels involved.

Table 2.1.3
Ions in Crystals Exhibiting Gain

Wavelength (μm)	Ion	Crystal	Temperature (K)	Reference
0.186 ^(a)	Nd ³⁺	LiYF ₄	300	1
~0.337	Ag ⁺	RbBr, KI	5	4,5
0.388–0.524	Ti ⁴⁺	Li ₂ GeO ₃	300	6
0.407	Tl ⁺	CsI	—	9
0.420	Tl ⁺	KI	—	10
0.442	In ⁺	KCl	—	11
0.500–0.550	UO ₂ ²⁺	Ca(UO ₂)(PO ₄)·H ₂ O	—	12
0.5145	Cu ⁺	Na- β "-alumina ^(b)	300	13
0.6328	Cu ⁺	Ag- β "-alumina	300	13
0.700–0.720	Rh ²⁺	RbCaF ₃	300	14
0.910	Cr ³⁺	LiNbO ₃	300	15
0.927	Cr ³⁺	LiNbO ₃	300	16
1.061 ^(c)	Nd ³⁺	Gd ₃ (Sc,Ga) ₅ O ₁₂ :Cr	300	17
1.064	V ²⁺	KMgF ₃	—	18
~1.080 ^(d)	Nd ³⁺	ZnS film	77	19
1.15	Mn ⁵⁺	Ca ₂ PO ₄ Cl	300	20
1.15–1.5	Cr ⁴⁺	CaGd ₄ (SiO ₄) ₃ O	300	21
~1.2	Mn ⁵⁺	Sr ₅ (PO ₄) ₃ Cl	300	20
1.319	Dy ³⁺	LaCl ₃	300	22
1.338	Dy ³⁺	LaCl ₃	300	22

(a) Because of the presence of excited state absorption, a negative net-induced gain coefficient was measured.

(b) Typical composition: Na_{1.67}Mg_{0.67}Al_{10.33}O₁₉.

(c) X-ray induced optical gain.

(d) Direct current electroluminescence (DCEL) and cathodoluminescence.

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Table 2.1.4
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
0.172	Nd ³⁺	LaF ₃	300	1–4
0.285–0.297	Ce ³⁺	LiSrAlF ₆	300	5,6
0.286	Ce ³⁺	LaF ₃	300	7
0.288	Ce ³⁺	LiCaAlF ₆	300	6,8
0.306–0.315	Ce ³⁺	LiYF ₄	300	7,9
0.3146 ^(a)	Gd ³⁺	Y ₃ Al ₅ O ₁₂	300	10
0.323–0.328	Ce ³⁺	LiYF ₄	300	7,9,11
0.323–0.335	Ce ³⁺	LiLuF ₄	300	12
0.335	Ag ⁺	KI, RbBr, CsBr	5	13
0.345	Ce ³⁺	BaY ₂ F ₈	300	14
0.38006	Nd ³⁺	LaF ₃	20–77	15
0.38052	Nd ³⁺	LaF ₃	20–77	15
0.413	Nd ³⁺	LiYF ₄	12	77
0.4502	Tm ³⁺	LiYF ₄	≤70	18
0.45020	Tm ³⁺	LiYF ₄	75	19
0.4526	Tm ³⁺	LiYF ₄	300	20
~0.455 ^(b)	Nd ³⁺	YAl ₃ (BO ₃) ₄	300	1018
0.456	Tm ³⁺	BaY ₂ F ₈ :Yb	300	21
0.4697	Er ³⁺	LiYF ₄	35	22
0.479	Pr ³⁺	LiYF ₄	300	23
0.48 ^(b,c)	Cr ³⁺	La ₃ Ga ₅ SiO ₁₄	300	1017
0.482	Tm ³⁺	BaY ₂ F ₈ :Yb	300	21
0.4835	Tm ³⁺	LiYF ₄	≤160	18
0.4879	Pr ³⁺	Y ₃ Al ₅ O ₁₂	4–32	657
0.488	Pr ³⁺	SrLaGa ₃ O ₇	≤230	24
0.4892	Pr ³⁺	LaCl ₃	5.5–14	25
0.4892	Pr ³⁺	(La,Pr)Cl ₃	14	26–28
0.5 ^(b,c)	Cr ³⁺	Ca ₂ Ga ₂ SiO ₇	300	1017
0.5 ^(b,c)	Cr ³⁺	Sr ₃ Ga ₂ GeO ₁₄	300	1017
0.512	Tm ³⁺	BaY ₂ F ₈ :Yb	300	21
0.52 ^(b,c)	Cr ³⁺	La ₃ Ga ₅ GeO ₁₄	300	1017
0.522	Pr ³⁺	GdLiF ₄	300	29
0.5236 ^(b)	Nd ³⁺	LiYF ₄	300	316
0.5241 ^(b)	Nd ³⁺	LaBGeO ₅	300	1013–1015
0.5298	Pr ³⁺	(La,Pr)Cl ₃	12	26–28

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
0.5241(b)	Nd ³⁺	LaBGeO ₅	300	1013-1015
0.5298	Pr ³⁺	(La,Pr)Cl ₃	12	26-28
~0.53(b)	Nd ³⁺	YAl ₃ (BO ₃) ₄	300	1019,1020
0.53(b,c)	Cr ³⁺	La ₃ Ga _{5.5} Nb _{0.5} O ₁₄	300	1017
0.530(b)	Nd ³⁺	YAl ₃ (BO ₃) ₄	300	47
0.530(b)	Nd ³⁺	Ca ₄ GdO(BO ₃) ₃	300	1033
0.532	Pr ³⁺	LaBr ₃	<300	30
0.5323(b)	Nd ³⁺	La ₃ Ga _{5.5} Nb _{0.5} O ₁₄	300	1016
0.5335(b)	Nd ³⁺	La ₃ Ga ₅ SiO ₁₄	300	1016,1022,1023
0.5337(b)	Nd ³⁺	La ₃ Ga ₅ GeO ₁₄	300	1016
0.5344(b)	Nd ³⁺	Ca ₂ Ga ₂ SiO ₇	300	1016
0.5347(b)	Nd ³⁺	Sr ₃ Ga ₂ GeO ₁₄	300	1017
0.536	XeF	Ar	20	16,17
0.5378	Pr ³⁺	LiYF ₄	110	31
0.5380	Pr ³⁺	LiLuF ₄	110	32,33
0.54(b,c)	Cr ³⁺	La ₃ Ga _{5.5} Ta _{0.5} O ₁₄	300	1017
0.5425(b)	Nd ³⁺	LiNbO ₃ :MgO	408–417	1006
0.544075	Er ³⁺	LiYF ₄	20	34
0.5441(b)	Nd ³⁺	LiNbO ₃ :MgO	300	1009-1011
0.5445	Tb ³⁺	LiYF ₄	300	35
0.545	Pr ³⁺	GdLiF ₄	300	29
0.5457(b)	Nd ³⁺	LiNbO ₃ :MgO	300	1009-1011
~0.546(b)	Nd ³⁺	LiNbO ₃ :Sc ₂ O ₃	300	1012
0.5464(b)	Nd ³⁺	LiNbO ₃ :MgO	300	1009-1011
0.5465(b)	Nd ³⁺	LiNbO ₃ :MgO	~425	36,1008
0.5467(b)	Nd ³⁺	LiNbO ₃ :MgO	~360	1005
~0.547	Nd ³⁺	LiNbO ₃ :MgO	300	855
0.547	Nd ³⁺	LiNbO ₃ :MgO	300	81
0.5496	Er ³⁺	(Y,Er)AlO ₃	30–77	37
0.550965	Er ³⁺	LiYF ₄	49	34
0.551	Er ³⁺	LiYF ₄	300	38
0.551	Er ³⁺	LiYF ₄	300	40,41
0.551	Er ³⁺	LiYF ₄	40	42
0.551	Er ³⁺	LiYF ₄	60	863
0.551	Er ³⁺	LiYF ₄ :Yb	300	1030
0.5512	Ho ³⁺	CaF ₂	77	44
0.551251	Er ³⁺	LiYF ₄	49	38

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
0.5515	Ho ³⁺	B(Y,Yb) ₂ F ₈	77	45
0.5540	Er ³⁺	Ba(Y,Er) ₂ F ₈	77	46
0.5606	Er ³⁺	LiYF ₄	<40	47
0.560660	Er ³⁺	LiYF ₄	20	34
0.561	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	39
0.561	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	39
0.5617	Er ³⁺	Ba(Y,Er) ₂ F ₈	77	46
0.5932	Sm ³⁺	TbF ₃	116	48
0.5984	Pr ³⁺	PrF ₃	15	49
0.5985	Pr ³⁺	LaF ₃	110	50,51
0.5985	Pr ³⁺	LaF ₃	77	52
0.6001	Pr ³⁺	LaF ₃	110	50,51
0.6042	Pr ³⁺	LiLuF ₄	110	32,33
0.6044	Pr ³⁺	LiYF ₄	300	53
0.6045	Pr ³⁺	GdLiF ₄	300	29
0.6048	Pr ³⁺	LiPrP ₄ O ₁₄	300	54
0.607	Pr ³⁺	GdLiF ₄	300	29
0.6071	Pr ³⁺	BaY ₂ F ₈	110, 300	55,56
0.6071	Pr ³⁺	LiLuF ₄	110	32,33
0.6071	Pr ³⁺	LiYF ₄	110–200	31
0.6073	Pr ³⁺	LiYF ₄	300	53
0.6092	Pr ³⁺	LiYF ₄	300	53
0.6105	Pr ³⁺	Ca(NbO ₃) ₂	110	57
0.6113	Eu ³⁺	Y ₂ O ₃	220	58
0.6116	Ti ³⁺	YA1O ₃	300	59
0.616	Pr ³⁺	Y ₃ Al ₅ O ₁₂	4-140	657
0.6130	Pr ³⁺	LiYF ₄	300	53
0.6139	Pr ³⁺	YA1O ₃	110	60-62
0.6139	Pr ³⁺	YA1O ₃	300	63
0.6155	Pr ³⁺	LuA1O ₃	110	61,62
0.6158	Pr ³⁺	LiYF ₄	300	53
0.6164	Pr ³⁺	(Pr,La)Cl ₃	65,300	26-28
0.6164	Pr ³⁺	LaCl ₃	8, 65	64
0.617	Pr ³⁺	PrCl ₃	300	30
0.6180	Pr ³⁺	LiYF ₄	300	53

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
0.6193	Eu ³⁺	YVO ₄	90	66
0.620	Pr ³⁺	PrCl ₃	300	65
0.6201	Pr ³⁺	LiYF ₄	300	53
0.621	Pr ³⁺	LaBr ₃	<300	30
0.6213	Pr ³⁺	YA1O ₃	110	61,62
0.6216	Pr ³⁺	YA1O ₃	300	63
0.622	Pr ³⁺	PrCl ₃	300	30
0.632	Pr ³⁺	LaBr ₃	< 70	30
0.637	Pr ³⁺	(La,Pr)P ₅ O ₁₄	300	68
0.6374	Pr ³⁺	PrP ₅ O ₁₄	300	69-71
0.6388	Pr ³⁺	LiYF ₄	300	53
0.6388	Pr ³⁺	BaY ₂ F ₈	300	72
0.6395	Pr ³⁺	LiYF ₄	110, 300	31,75
0.6396	Pr ³⁺	LiPrP ₄ O ₁₂	300	74
0.6399	Pr ³⁺	LiLuF ₄	110	32,33
0.64	Pr ³⁺	LiYF ₄	300	73
0.6401	Pr ³⁺	LiLuF ₄	300	32,33
0.6444	Pr ³⁺	LiYF ₄	300	53
0.645	Pr ³⁺	SrLaGa ₃ O	300	24
0.6451	Pr ³⁺	(Pr,La)Cl ₃	65, 300	26-28
0.6451	Pr ³⁺	PrBr ₃	300	26
0.6452	Pr ³⁺	LaCl ₃	300	25
0.647	Pr ³⁺	LaBr ₃	<300	30
0.647	Pr ³⁺	PrCl ₃	300	26
0.649	Tm ³⁺	BaY ₂ F ₈ :Yb	300	21
0.6490	Tm ³⁺	BaY ₂ F ₈	300	79
0.6497	Pr ³⁺	CaWO ₄	110	57
0.650	Tm ³⁺	LiYF ₄ :Yb	300	80
0.6571 ^(b)	Nd ³⁺	LaBGeO ₅	300	1013-1015
~0.66 ^(b)	Nd ³⁺	YAl ₃ (BO ₃) ₄	300	1021
0.66–1.06	Ti ³⁺	Al ₂ O ₃	300	82-112
0.6624	Pr ³⁺	YA1O ₃	300	63
0.67	Er ³⁺	BaYb ₂ F ₈	300	78
0.6700	Er ³⁺	Ba(Y,Yb) ₂ F ₈	77	45
0.6700	Er ³⁺	BaYb ₂ F ₈	110	45,115
0.6703	Pr ³⁺	LiYF ₄	300	53
0.6709	Er ³⁺	Ba(Y,Er) ₂ F ₈	77	46

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
0.6709	Er ³⁺	Ba(Y,Yb) ₂ F ₈	77	45
0.671	Er ³⁺	LiYF ₄	300	40
0.6799	Cr ³⁺	BeAl ₂ O ₄	77	119
0.6803	Cr ³⁺	BeAl ₂ O ₄	77, 300	118,121,122
0.685	Cr ³⁺	Be ₃ Al ₂ Si ₆ O ₁₈	300	123
0.6874	Cr ³⁺	Y ₃ Al ₅ O ₁₂	~77	124
0.6929(R ₂)	Cr ³⁺	Al ₂ O ₃	300	125
0.6934	Cr ³⁺	Al ₂ O ₃	77	126-128
0.6935-8	Pr ³⁺	BaY ₂ F ₈	110, 190	55,56
0.6943(R ₁)	Cr ³⁺	Al ₂ O ₃	300	131-135,138,297
0.6954	Pr ³⁺	LiYF ₄	110-180	31
0.6958	Pr ³⁺	LiLuF ₄	110	32,33
0.6969	Sm ²⁺	SrF ₂	4.2	156
0.6977	Pr ³⁺	LiYF ₄	300	53
0.6977	Pr ³⁺	LiLuF ₄	110	32
0.6994	Pr ³⁺	LiYF ₄	300	53
0.70-0.82	Cr ³⁺	BeAl ₂ O ₄	300-583	140-152
0.7009(N ₂)	2Cr ³⁺	Al ₂ O ₃	77	153
0.701-0.818	Cr ³⁺	BeAl ₂ O ₄	300	121,154
0.7015	Er ³⁺	LiYF ₄	300	39
0.7037	Er ³⁺	Ba(Y,Er) ₂ F ₈	77	46
0.7041(N ₁)	2Cr ³⁺	Al ₂ O ₃	77	153
0.7055	Pr ³⁺	LiYF ₄	300	53
0.7082	Pr ³⁺	LiYF ₄	300	53
0.7083	Sm ²⁺	CaF ₂	65-90	157
0.7085	Sm ²⁺	CaF ₂	20	157-160
0.717	Pr ³⁺	(La,Pr)P ₅ O ₁₄	300	68
0.7190	Pr ³⁺	LiYF ₄	180-250	31
0.7191	Pr ³⁺	BaY ₂ F ₈	300	73
0.7192	Pr ³⁺	LiLuF ₄	110	32,33
0.7194	Pr ³⁺	LaF ₃	110	50,51
0.7195	Pr ³⁺	YA1O ₃	300	63
0.7195	Pr ³⁺	YA1O ₃	110	60,62
0.7197	Pr ³⁺	YA1O ₃	300	61,61
0.7198	Pr ³⁺	LaF ₃	300	50,51,161

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
0.72–0.84	Cr ³⁺	LiCaAlF ₆	300	162,163
0.720–0.842	Cr ³⁺	Be ₃ Al ₂ Si ₆ O ₁₈	300	164-166
0.7204	Pr ³⁺	LiPrP ₄ O ₁₄	300	54
0.7206	Pr ³⁺	LiYF ₄	300	168
0.7207	Sm ²⁺	CaF ₂	85–90	157
0.7209	Pr ³⁺	LiYF ₄	300	53
0.7215	Pr ³⁺	LiLuF ₄	300	32,33
0.722	Pr ³⁺	YA1O ₃	300	169
0.7222	Pr ³⁺	LiYF ₄	300	53
0.7287	Sm ²⁺	CaF ₂	110–130	157
0.72952	Nd ³⁺	LiYF ₄	12	77
0.73–0.95	Ti ³⁺	BeAl ₂ O ₄	300	170-172
0.7310	Sm ²⁺	CaF ₂	155	157
0.74	Cr ³⁺	Y ₃ Ga ₅ O ₁₂	300	173
0.742–0.842	Cr ³⁺	Gd ₃ Sc ₂ Ga ₃ O ₁₂	300	174-178
0.7437	Pr ³⁺	YA1O ₃	300	63
0.744–0.788	Cr ³⁺	BeAl ₂ O ₄	300	179
0.745	Sm ²⁺	CaF ₂	210	157
0.7469	Pr ³⁺	YA1O ₃	300	60,61,63
0.748–0.832	Cr ³⁺	Na ₃ Ga ₃ Li ₃ F ₁₂	300	180
0.7496	Pr ³⁺	LuAlO ₃	300	169
0.7498	Ho ³⁺	LiYF ₄	90, 300	167,181
0.75–0.81	Cr ³⁺	Gd ₃ Sc ₂ Al ₃ O ₁₂	300	174,175,182-185
0.750–0.950	Cr ³⁺	LiSr _{0.8} Ca _{0.2} AlF ₆	300	186
0.7501	Ho ³⁺	LiLuF ₄	110	32
0.7505	Ho ³⁺	LiYF ₄	300	187
0.7505	Ho ³⁺	LiLuF ₄	110	32
0.7516	Ho ³⁺	LiYF ₄	116	181
0.753-0.946	Ti ³⁺	BeAl ₂ O ₄	300	189
0.7537	Pr ³⁺	YA1O ₃	300	63
0.7555	Ho ³⁺	LiYF ₄	116	181
0.7577	Ho ³⁺	YA1O ₃	110–300	190
0.76	Cr ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂	300	173
0.7610	Ho ³⁺	YA1O ₃	110–300	190
0.766–0.865	Cr ³⁺	KZnF ₃	300	191-195
0.767	Cr ³⁺	Y ₃ Sc ₂ Al ₃ O ₁₂	300	196
0.7670	Cr ³⁺	Al ₂ O ₃	300	197

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
0.769	Cr^{3+}	$\text{Gd}_3\text{Ga}_5\text{O}_{12}$	300	174
0.773–0.814	Cr^{3+}	$(\text{Gd,Ca})_3(\text{Ga,Mn,Zr})_5\text{O}_{12}$	300	198
0.775–0.816	Cr^{3+}	KZnF_3	80	191,192
0.78–0.92	Cr^{3+}	LiSrAlF_6	300	196,199,200
0.780–1.010	Cr^{3+}	LiSrAlF_6	300	201
0.787–0.892	Cr^{3+}	ScBO_3	300	162,202,203
0.79–0.87	Cr^{3+}	$\text{BeAl}_6\text{O}_{10}$	300	204
0.790–0.825	Cr^{3+}	KZnF_3	200	191,192
0.792	Tm^{3+}	$\text{LiYF}_4\text{:Yb}$	300	80
0.792	Cr^{3+}	ScBeAlO_4	300	21
0.799	Tm^{3+}	$\text{BaY}_2\text{F}_8\text{:Yb}$	300	207
0.815–1.22	Cr^{3+}	$\text{La}_3\text{Ga}_5\text{SiO}_{14}$	300	208,209,1017
0.80	Cr^{3+}	$\text{Al}_2(\text{WO}_4)_3$	300	210
0.810	Tm^{3+}	$\text{LiYF}_4\text{:Yb}$	300	80
0.820	Cr^{3+}	LiSrGaF_6	300	212,1025
0.83	Cr^{3+}	$(\text{La,Lu})_3(\text{La,Ga})_2\text{Ga}_3\text{O}_{12}$	300	174
0.8425	Er^{3+}	BaEr_2F_8	110	115
0.8430	Er^{3+}	$\text{CaF}_2\text{-YF}_3$	77	215,216
0.8446	Er^{3+}	CaF_2	300	235
0.8456	Er^{3+}	$\text{CaF}_2\text{-YF}_3$	77	215,216
0.8456	Er^{3+}	$\text{CaF}_2\text{-HoF}_3\text{-ErF}_3$	77	217
0.8456	Er^{3+}	$\text{CaF}_2\text{-HoF}_3\text{-ErF}_3\text{-TmF}_3$	77	217
0.8467	Er^{3+}	$\text{KGd}(\text{WO}_4)_2$	110	218
0.8468	Er^{3+}	$\text{KGd}(\text{WO}_4)_2$	300	218–220
0.8471	Er^{3+}	$\text{Ca}_3\text{Ga}_2\text{Ge}_3\text{O}_{12}$	110	221
0.8474	Er^{3+}	$\text{KY}(\text{WO}_4)_2$	110	218
0.8479	Er^{3+}	$\text{KLu}(\text{WO}_4)_2$	110	218
0.84965	Er^{3+}	YAlO_3	77	129,130
0.84975	Er^{3+}	YAlO_3	300	129,130
0.85	Er^{3+}	LiYF_4	300	220
0.85	Er^{3+}	$\text{KLu}(\text{WO}_4)_2$	300	207
0.8500	Er^{3+}	LiYF_4	300	222
0.8501	Er^{3+}	$\text{LiY}_{0.5}\text{Er}_{0.5}\text{F}_4$	113, 161	181
0.8503	Er^{3+}	$\text{LiYF}_4\text{:Pr}$	110, 300	224,226,329
0.8506	Er^{3+}	LiLuF_4	110	32

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
0.8507	Er ³⁺	LiLuF ₄	300	32,33
0.85165	Er ³⁺	YAlO ₃	77	129,130
0.852–1.005	Cr ³⁺	SrAlF ₅	300	227,228
0.853	Er ³⁺	Bi ₄ Ge ₃ O ₁₂	77	229
0.8535	Er ³⁺	LiYF ₄	110	226
0.8535	Er ³⁺	LiY _{0.5} Er _{0.5} F ₄	113, 163	181
0.8537	Er ³⁺	LiYF ₄	116, 300	181,231
0.8538	Er ³⁺	BaEr ₂ F ₈	104–123	232
0.8540	Er ³⁺	LiErF ₄	110	233
0.8542	Er ³⁺	LiLuF ₄	300	32,33
0.8543	Er ³⁺	BaEr ₂ F ₈	110	115
0.8543	Er ³⁺	LiLuF ₄	110	32
0.8548	Er ³⁺	CaF ₂	77	235
0.8594	Er ³⁺	YAlO ₃	300	129,130
0.8610	Er ³⁺	KGd(WO ₄) ₂	110	218
0.8615	Er ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	110	221
0.8621	Er ³⁺	KY(WO ₄) ₂	300	218,236
0.8621	Er ³⁺	KY(WO ₄) ₂	110	218
0.8624	Er ³⁺	KEr(WO ₄) ₂	110	218
0.8624	Er ³⁺	Y ₃ Al ₅ O ₁₂	77	237
0.8625	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	300	218
0.8627	Er ³⁺	Y ₃ Al ₅ O ₁₂	77, 300	129,238
0.8628	Er ³⁺	Er ₃ Al ₅ O ₁₂	110	218
0.8631	Er ³⁺	KLu(WO ₄) ₂	110	218
0.8631	Er ³⁺	Lu ₃ Al ₅ O ₁₂	110	218
0.86325	Er ³⁺	KLu(WO ₄) ₂	110	218
0.86325	Er ³⁺	Lu ₃ Al ₅ O ₁₂	77	239
0.8633	Er ³⁺	KLu(WO ₄) ₂	300	218
0.87–1.21	Cr ³⁺	Ca ₃ Ga ₂ Ge ₄ O ₁₄	300	241,1017
0.88–1.22	Cr ³⁺	La ₃ Ga ₅ GeO ₁₄	300	241,242,1017
0.890	Cr ³⁺	LiSrCrF ₆	300	243
0.8910	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	244
0.895	Cr ³⁺	Sr ₃ Ga ₂ Ge ₄ O ₁₄	300	1017
0.8999	Nd ³⁺	Y ₃ Al ₃ O ₁₂	300	244
0.90–1.15	Cr ³⁺	Sr ₃ Ga ₂ Ge ₄ O ₁₄	300	241,242
0.9010	Pr ³⁺	BaY ₂ F ₈	110	245
0.9066	Pr ³⁺	LiYF ₄	110	241,246

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
0.9068	Pr^{3+}	LiLuF_4	110–250	246
0.9069	Pr^{3+}	LiYF_4	300	246
0.9–1.1	Cr^{3+}	$\text{Ca}_3\text{Ga}_2\text{Ge}_4\text{O}_{14}$	300	240,241
0.9–1.25	Cr^{3+}	$\text{La}_3\text{Ga}_{5.5}\text{Nb}_{0.5}\text{O}_{14}$	300	240,1017
0.911	Nd^{3+}	$\text{SrGdGa}_3\text{O}_7$	31	247
0.912	Nd^{3+}	Y_2SiO_5	300	248
0.9106	Nd^{3+}	$\text{Ba}_3\text{LaNb}_3\text{O}_{12}$	300	249
0.9137	Nd^{3+}	$\text{KY}(\text{WO}_4)_2$	77	250-252
0.9145	Nd^{3+}	CaWO_4	77	253
0.9145	Pr^{3+}	LiYF_4	110	246
0.9148	Pr^{3+}	BaY_2F_8	110	245
0.9150	Pr^{3+}	BaY_2F_8	300	245
0.9185	Pr^{3+}	LaF_3	110	245
0.9190	Pr^{3+}	LaF_3	300	245
0.925–1.24	Cr^{3+}	$\text{La}_3\text{Ga}_{5.5}\text{Ta}_{0.5}\text{O}_{14}$	300	240,241
0.9266 ^(b)	Tm^{3+}	LiNbO_3	77	65
0.930	Nd^{3+}	YAlO_3	300	256
0.9308	Pr^{3+}	YAlO_3	110	62
0.9312	Pr^{3+}	YAlO_3	300	62
0.936	Nd^{3+}	$\text{Gd}_3\text{Sc}_2\text{Ga}_3\text{O}_{12}$	300	258,259
0.9385	Nd^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	244
0.9395	Pr^{3+}	YA1O_3	300	63
0.941	Nd^{3+}	$\text{CaY}_2\text{Mg}_2\text{Ge}_3\text{O}_{12}$	300	265
0.946	Nd^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	260–300	262-263
0.9460	Nd^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	266
0.9473	Nd^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}$	77	267
0.9660	Pr^{3+}	YA1O_3	300	63
0.979	Ho^{3+}	LiHoF_4	90	268,269
0.9794	Ho^{3+}	LiYF_4	90, 300	67
0.98–1.09	Cr^{3+}	ZnWO_4	77	271
0.985	Yb^{3+}	$\text{Ca}_4\text{Sr}(\text{PO}_4)_3\text{F}$	300	1034
0.9960	Pr^{3+}	YAlO_3	300	62
1.008	Yb^{3+}	LiNbO_3	300	999
1.0143	Ho^{3+}	LiYF_4	90, 300	67,181
1.0183	Ho^{3+}	LiLuF_4	110	32

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.0230	Yb ³⁺	Lu ₃ Ga ₅ O ₁₂	77	276
1.0232	Yb ³⁺	Gd ₃ Ga ₅ O ₁₂	77	276
1.0233	Yb ³⁺	Y ₃ Ga ₅ O ₁₂ :Nd	77	276
1.025	Yb ³⁺	KY(WO ₄) ₂	300	277
1.025	Yb ³⁺	KGd(WO ₄) ₂	300	277
1.0293	Yb ³⁺	Y ₃ Al ₅ O ₁₂	77	276
1.0293	Yb ³⁺	(Y,Yb) ₃ Al ₅ O ₁₂	77	276
1.0294	Yb ³⁺	Lu ₃ Al ₅ O ₁₂	77	276
1.0296	Yb ³⁺	Y ₃ Al ₅ O ₁₂	77	278
1.0297	Yb ³⁺	Lu ₃ Al ₅ O ₁₂	77	276
1.0297	Yb ³⁺	Y ₃ Al ₅ O ₁₂ :Nd	200	276
1.0298	Yb ³⁺	Y ₃ Al ₅ O ₁₂ :Nd	210	276
1.0299	Yb ³⁺	Gd ₃ Sc ₂ Al ₃ O ₁₂	77	279
1.0299	Yb ³⁺	Lu ₃ Sc ₂ Al ₃ O ₁₂	77	279
1.03	Yb ³⁺	Y ₃ Al ₅ O ₁₂	300	280,281
1.03	Yb ³⁺	Y ₃ Al ₅ O ₁₂ :Nd	300	282
1.03	Yb ³⁺	Lu ₃ Al ₅ O ₁₂	300	283
1.030	Yb ³⁺	LiNbO ₃	300	999
1.031	Yb ³⁺	Y ₃ Al ₅ O ₁₂	300	311
1.0311	Ho ³⁺	YAlO ₃	110–300	190,241
1.0336	Yb ³⁺	CaF ₂	120	285
1.034	Yb ³⁺	BaCaBO ₃ F	300	275
1.0369	Nd ³⁺	CaF ₂ -SrF ₂	300	286
1.0370	Nd ³⁺	CaF ₂	300	137
1.0370–1.0395	Nd ³⁺	SrF ₂	300–530	1024
1.04	Pr ³⁺	Ca(NbO ₃) ₂	77	753
1.04	Pr ³⁺	SrMoO ₄	–	290
1.0400	Nd ³⁺	LaF ₃	77	291-293
1.0404	Nd ³⁺	CeF ₃	77	294,295
1.04065–1.0410	Nd ³⁺	LaF ₃	300–430	137,985
1.0410	Nd ³⁺	CeF ₃	300	294,295
1.0412	Nd ³⁺	KYF ₄	300	559,573
1.042–1.075	Nd ³⁺	Na _{0.4} Y _{0.6} F _{2.2}	300	298
1.043	Yb ³⁺	Ca ₅ (PO ₄) ₃ F	300	284,311
1.0437	Nd ³⁺	SrF ₂	77	155
1.044	Yb ³⁺	Sr ₅ (VO ₄) ₃ F	300	1034
1.0445	Nd ³⁺	SrF ₂	300	155

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.0446	Nd ³⁺	SrF ₂	500-550	155
1.0448	Nd ³⁺	CaF ₂	50	300-302
1.0451	Nd ³⁺	LaF ₃	77	303-305
1.0456	Nd ³⁺	CaF ₂	50	301,302
1.0457	Nd ³⁺	CaF ₂	77	301,302
1.046	Yb ³⁺	Ca ₄ Sr(PO ₄) ₃ F	300	1034
1.046	Yb ³⁺	Ca ₃ Sr ₂ (PO ₄) ₃ F	300	1034
1.046–1.064	Nd ³⁺	LiNdP ₄ O ₁₂	300	306,307
1.0461	Nd ³⁺	CaF ₂ -YF ₃	300	308,309
1.0461–1.0468	Nd ³⁺	CaF ₂	300–530	137
1.0466	Nd ³⁺	CaF ₂	50	301,302
1.0467	Nd ³⁺	CaF ₂	77	301,302
1.0468	Pr ³⁺	CaWO ₄	77	310
1.047	Yb ³⁺	Sr ₅ (PO ₄) ₃ F	300	311,312
1.047	Nd ³⁺	LiGdF ₄	300	313
1.047	Nd ³⁺	LiNdP ₄ O ₁₂	300	317,319
1.047	Nd ³⁺	LiYF ₄	300	314-316
[1.047–1.078]	Nd ³⁺	NdP ₅ O ₁₄	300	307
1.0471	Nd ³⁺	LiYF ₄	300	33,314,321,322, 327
1.0472	Nd ³⁺	LiLuF ₄	300	32,33,983
1.0475	Nd ³⁺	LaBGeO ₅	300	330
1.0477	Nd ³⁺	Li(Nd,La)P ₄ O ₁₂	300	331
1.0477	Nd ³⁺	Li(Nd,Gd)P ₄ O ₁₂	30	331
1.048	Nd ³⁺	Li(Bi,Nd)P ₄ O ₁₂	300	332
1.048	Nd ³⁺	Li(Nd,La)P ₄ O ₁₂	300	333-355
1.048	Nd ³⁺	Li(Nd,Gd)P ₄ O ₁₂	300	273
1.048	Nd ³⁺	K ₅ Nd,Ce)Li ₂ F ₁₀	300	357
1.0480	Nd ³⁺	CaF ₂	50	301,302
1.0481	Nd ³⁺	LiKYF ₅	300	358,359
1.0482	Nd ³⁺	LaBGeO ₅	300	330
1.0482	Nd ³⁺	NaLa(MoO ₄) ₂	300	361
1.0483	Nd ³⁺	BaLu ₂ F ₈	300	1035
1.0486	Nd ³⁺	LaF ₃ -SrF ₂	300	362
1.049–1.077	Nd ³⁺	NaNP ₄ O ₁₂	300	307
1.0491	Nd ³⁺	SrAl ₁₂ O ₁₉	300	364,365

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.0493	Nd ³⁺	BaY ₂ F ₈	77	366
1.0493	Nd ³⁺	Sr ₂ Y ₅ F ₁₉	300	367
1.0495	Pr ³⁺	CaWO ₄	300	73
1.0495	Nd ³⁺	BaY ₂ F ₈	300	366
1.0495	Nd ³⁺	GdF ₃ -CaF ₂	300	369
1.0497	Nd ³⁺	SrAl ₂ O ₄	300	370
1.0498	Nd ³⁺	Ca ₂ Y ₅ F ₁₉	300	137
1.0498	Nd ³⁺	SrAl ₁₂ O ₁₉	300	313
1.05	Nd ³⁺	KNdP ₄ O ₁₂	300	317
1.05	Nd ³⁺	NdP ₅ O ₁₄	300	376
1.05	Nd ³⁺	LaP ₅ O ₁₄	300	376
1.05	Nd ³⁺	LiLuF ₄	300	32,33
1.0500	Nd ³⁺	CaF ₂ -ScF ₃	300	374
1.0505	Nd ³⁺	(Nd,La)P ₅ O ₁₄	300	378
1.0505	Nd ³⁺	5NaF-9YF ₃	300	379
1.0506	Nd ³⁺	5NaF-9YF ₃	300	379
1.0507	Nd ³⁺	CaF ₂	50	301,302
1.0507	Nd ³⁺	CdF ₂ -ScF ₃	300	380
1.051	Nd ³⁺	NaNdP ₄ O ₁₂	300	335,381,382
1.051	Nd ³⁺	YP ₅ O ₁₄	300	384
1.051 Nd ³⁺ (La, Nd) ³⁺	Nd ³⁺	(Y,Nd)P ₅ O ₁₄	300	399-403
300 347,385 1.051 Nd ³⁺ NdP ₅ O ₁₄				
300 384				
+ GdP ₅ O ₁₄ 300				
Nd ³⁺ NdP ₅ O ₁₄				
0510 Nd ³⁺ CdF ₂ -ScF ₃				
≤200 380				
+ (Nd,La)P ₅ O ₁₄				
1.0512 Nd ³⁺ NdP ₅ O ₁₄				
78 1.0512 Nd ³⁺ NdP ₅ O ₁₄				
390-391				
1.0513	Nd ³⁺	NdP ₅ O ₁₄	300	387
1.0515	Nd ³⁺	YP ₅ O ₁₄	300	384
1.0515	Nd ³⁺	NdP ₅ O ₁₄	300	355,388,389
1.0518	Nd ³⁺	BaLu ₂ F ₈	300	1035
1.052	Nd ³⁺	(Nd,La)P ₅ O ₁₄	300	390-398,617,621

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.052	Nd ³⁺	KNdP ₄ O ₁₂	300	289,335,382, 404-406
1.052	Nd ³⁺	K ₅ NdLi ₂ F ₁₀	300	357
1.052	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	407,412
1.0521	Nd ³⁺	BaF ₂ -YF ₃	300	413
1.0521	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	414
1.0521	Nd ³⁺	NdP ₅ O ₁₄	300	387
1.0521	Nd ³⁺	YF ₃	300	415
1.0523	Nd ³⁺	LaF ₃	77	291,416-418
1.0525	Nd ³⁺	YP ₅ O ₁₄	300	419
1.0526	Nd ³⁺	BaF ₂ -GdF ₃	300	413
1.0528	Nd ³⁺	SrF ₂ -GdF ₃	300	421
1.0528	Nd ³⁺	LiYF ₄	77	32,33
1.0529	Nd ³⁺	NdP ₅ O ₁₄	300	378
1.0529	Nd ³⁺	BaY ₂ F ₈	77	422
1.0529	Nd ³⁺	LiLuF ₄	110	32,33
1.053	Nd ³⁺	LiYF ₄	300	32,33,314-316
1.053	Nd ³⁺	(La,Nd)P ₅ O ₁₄	300	429,430
1.053–1.062	Nd ³⁺	Ca ₃ (Nb,Ga) ₂ Ga ₃ O ₁₂	300	428
1.0530	Nd ³⁺	LiYF ₄	300	321,322
1.0530	Nd ³⁺	BaY ₂ F ₈	300	366
1.0530	Nd ³⁺	CaF ₂ -LuF ₃	300	425
1.0530–1.059	Nd ³⁺	LaMgAl ₁₁ O ₁₉	300	432
1.0531	Nd ³⁺	LiLuF ₄	300	32,33
1.0532	Nd ³⁺	LiKYF ₅	300	358,359
1.0534–1.0563	Nd ³⁺	BaF ₂ -LaF ₃	300–920	435
1.0535	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	436
1.0535–1.0547	Nd ³⁺	CaF ₂ -SrF ₂ -BaF ₂ -YF ₃ -LaF ₃	300-550	137,438
1.0536	Nd ³⁺	CaF ₂ -YF ₃	110	439
1.0537	Nd ³⁺	BaF ₂ -CeF ₃	300	440
1.0538	Nd ³⁺	BaF ₂ -LaF ₃	77	435
1.0539–1.0549	Nd ³⁺	α -NaCaYF ₆	300–550	137,439,504,983
1.054	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	300	443
1.054	Nd ³⁺	LaAl ₁₁ MgO ₁₉	300	313,326
1.054–1.086	Nd ³⁺	LaAl ₁₁ MgO ₁₉	300	431,444,1025
1.0540	Nd ³⁺	CaF ₂ -YF ₃	300	137,308,309

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.0540	Nd ³⁺	BaF ₂	300	445
1.0540	Nd ³⁺	CaF ₂ -YF ₃	300	439
1.0543	Nd ³⁺	BaF ₂ -CeF ₃	300	413
1.0543	Nd ³⁺	SrF ₂ -ScF ₃	300	446
1.05436	Nd ³⁺	Ba ₂ MgGe ₂ O ₇	300	447
1.05437	Nd ³⁺	Ba ₂ ZnGe ₂ O ₇	300	448
1.0547	Nd ³⁺	LaMgAl ₁₁ O ₁₉	300	318,450,451
1.05499	Nd ³⁺	CsY ₂ F ₇	300	452
1.055	Nd ³⁺	Na ₃ Nd(PO ₄) ₂	300	373
1.055	Nd ³⁺	K ₃ (La,Nd)(PO ₄) ₂	300	373,454
1.055	Nd ³⁺	Na ₃ (La,Nd)(PO ₄) ₂	300	373
1.0550	Nd ³⁺	LaMgAl ₁₁ O ₁₉	77	439,455,546
1.0551	Nd ³⁺	Pb ₅ (PO ₄) ₃ F	300	456
1.0552	Nd ³⁺	LaMgAl ₁₁ O ₁₉	300	439,455,546
1.0554	Nd ³⁺	LiNdP ₄ O ₁₂	300	349
1.0554	Nd ³⁺	KY ₃ F ₁₀	300	461
1.0555	Nd ³⁺	CsGd ₂ F ₇	300	462
1.0555	Nd ³⁺	Ba ₅ (PO ₄) ₃ F	300	1027
1.0556	Nd ³⁺	SrF ₂ -LuF ₃	300	463
1.0560	Nd ³⁺	SrF ₂ -LuF ₃	300	464,465
1.0566	Nd ³⁺	SrAl ₄ O ₇	77	473
1.0566	Nd ³⁺	La ₂ Si ₂ O ₇	300	466
1.0566	Nd ³⁺	NdGaGe ₂ O ₇	110	467
1.0567	Nd ³⁺	SrF ₂ -YF ₃	300	468
1.0567	Nd ³⁺	GdGaGe ₂ O ₇	77	467
1.0568	Nd ³⁺	SrAl ₄ O ₇	77	473
1.0569	Nd ³⁺	NdGaGe ₂ O ₇	300	467,470
1.0570	Nd ³⁺	GdGaGe ₂ O ₇	300	467,472
1.0572	Nd ³⁺	LaSr ₂ Ga ₁₁ O ₂₀	300	234,439,546
1.0573	Nd ³⁺	CaMoO ₄	295	291,474,479
1.0574	Nd ³⁺	SrWO ₄	77	291
1.0575	Nd ³⁺	CsLa(WO ₄) ₂	300	241,475
1.0575	Nd ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂	77	427
1.05755	Nd ³⁺	Gd ₃ Sc ₂ Ga ₃ O ₁₂	77	477
1.0576	Nd ³⁺	SrAl ₄ O ₇	300	473
1.0576	Nd ³⁺	SrMoO ₄	295	291,479
1.0576	Nd ³⁺	La ₂ Si ₂ O ₇	300	466

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.0580	Nd ³⁺	BaF ₂ -LaF ₃	77	435
1.058	Nd ³⁺	Gd ₃ Sc ₂ Ga ₃ O ₁₂	300	358
1.0580	Nd ³⁺	Gd ₃ Sc ₂ Ga ₃ O ₁₂	77	477
1.0580	Nd ³⁺	KLa(MoO ₄) ₂	110	439
1.0581	Nd ³⁺	CsLa(WO ₄) ₂	110	241,475
1.0582	Nd ³⁺	Ca ₃ Ga ₄ O ₉	300	482
1.0582–1.0597	Nd ³⁺	CaWO ₄	300–700	137,483–487
1.0583	Nd ³⁺	LaF ₃	77	416–418
1.0583	Nd ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂	300	427
1.0583	Nd ³⁺	Y ₃ Ga ₅ O ₁₂	77	490,491
1.0583	Nd ³⁺	Ca ₃ (Nb,Ga) ₂ Ga ₃ O ₁₂	110	439,458
1.0584	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	77	490,492
1.0584	Nd ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂ :Cr	300	342,343
1.0584	Nd ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂	300	493
1.0584	Nd ³⁺	CaY ₂ Mg ₂ Ge ₃ O ₁₂	300	494
1.0585	Nd ³⁺	YAlO ₃	300	495
1.0585	Nd ³⁺	LiLa(MoO ₄) ₂	300	496
1.0585	Nd ³⁺	Sr ₅ (PO ₄) ₃ F	300	497
1.0585	Nd ³⁺	CaF ₂ -SrF ₂ -BaF ₂ -YF ₃ -LaF ₃	300–700	137
1.0585	Nd ³⁺	KLa(MoO ₄) ₂	300	498
1.0586	Nd ³⁺	Sr ₅ (PO ₄) ₃ F	300	499
1.0586	Nd ³⁺	PbMoO ₄	300	291,500
1.0587	Nd ³⁺	KLa(MoO ₄) ₂	300	439,498,501
1.0587	Nd ³⁺	CaWO ₄	300	17
1.0587	Nd ³⁺	Y ₃ Sc ₂ Al ₃ O ₁₂	77	476
1.0587	Nd ³⁺	Lu ₃ Ga ₅ O ₁₂	77	505
1.0588	Nd ³⁺	Ca ₃ (Nb,Ga) ₂ Ga ₃ O ₁₂	300	439,458,506
1.0589	Nd ³⁺	SrF ₂ -CeF ₃ -GdF ₃	300	421
1.0589	Nd ³⁺	Y ₃ Ga ₅ O ₁₂	300	490,492
1.05895	Nd ³⁺	CaAl ₄ O ₇	77	510
1.05896	Nd ³⁺	CaMg ₂ Y ₂ Ge ₃ O ₁₂	300	265,511
1.059	Nd ³⁺	(La,Sr)(Al,Ta)O ₃	300	512
1.059	Nd ³⁺	BaLaGa ₃ O ₇	300	513
1.059	Nd ³⁺	SrMoO ₄	77	291,497
1.059	Nd ³⁺	NaY(WO ₄) ₂	300	516

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.059	Nd ³⁺	Na _{1+x} Mg _x Al _{11-x} O ₁₇	300	517
1.059	Nd ³⁺	Na ₂ Nd ₂ Pb ₆ (PO ₄) ₆ Cl ₂	300	520,521
1.0590	Nd ³⁺	SrF ₂ -CeF ₃	300	518
1.0590	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	77	519
1.0590	Nd ³⁺	SrF ₂ -CeF ₃	300	439
1.0591	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	300	522
1.0591	Nd ³⁺	Lu ₃ Sc ₂ Al ₃ O ₁₂	300	279
1.0591	Nd ³⁺	Ba ₃ LaNb ₃ O ₁₂	77	249
1.0591	Nd ³⁺	LaGaGe ₂ O ₇	300	525,526
1.05915	Nd ³⁺	Gd ₃ Sc ₂ Al ₃ O ₁₂	77	279,527
1.0592	Nd ³⁺	NaGaGe ₂ O ₇	110	470
1.0592	Nd ³⁺	Nd ₃ Ga ₅ O ₁₂	110	470
1.0593	Nd ³⁺	Sr ₄ Ca(PO ₄) ₃	300	499
1.0594	Nd ³⁺	Lu ₃ Ga ₅ O ₁₂	300	529
1.0594	Nd ³⁺	SrF ₂ -CeF ₃	110	439
1.0595	Nd ³⁺	5NaF-9YF ₃	300	530
1.0595	Nd ³⁺	Y ₃ Sc ₂ Al ₃ O ₁₂	300	427,504
1.0595	Nd ³⁺	NaLa(MoO ₄) ₂	300	439,533,534,536
1.0595	Nd ³⁺	BaLaGa ₃ O ₇	300	249
1.0595	Nd ³⁺	LiGd(MoO ₄) ₂	110	439,458
1.0595–1.0613	Nd ³⁺	LaF ₃	380–820	137
1.0596	Nd ³⁺	CaAl ₄ O ₇	300	510
1.0596	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	300	519
1.0596	Nd ³⁺	NaLuGeO ₄	77	539,540
1.0596	Nd ³⁺	SrF ₂	300	541
1.0597	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	300	675
1.0597–1.0583	Nd ³⁺	SrF ₂ -LaF ₃	300–800	137
1.0597–1.0629	Nd ³⁺	α -NaCaYF ₆	1000–300	137
1.05975	Nd ³⁺	Y ₃ Ga ₅ O ₁₂	77	490,491
1.0599	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	77	490,492
1.0599	Nd ³⁺	Lu ₃ Sc ₂ Al ₃ O ₁₂	300	279
1.0599	Nd ³⁺	LiGd(MoO ₄) ₂	300	252,257
1.05995	Nd ³⁺	Gd ₃ Sc ₂ Al ₃ O ₁₂	300	279,527
~1.06	Nd ³⁺	(Gd,Ca) ₃ (Ga,Mg,Zr) ₅ O ₁₂ :Cr	300	502,503
~1.06	Nd ³⁺	CaGd ₄ (SiO ₄) ₃ O	300	551
~1.06	Nd ³⁺	GdVO ₄	300	550
1.06	Nd ³⁺	Gd ₃ Sc ₂ Al ₃ O ₁₂	300	279,527

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.06	Nd ³⁺	NaLa(MoO ₄) ₂	300	536
1.06	Nd ³⁺	NaGd(WO ₄) ₂	300	476
1.06	Nd ³⁺	Na(Nd,Gd)(WO ₄) ₂	77	476
1.06	Nd ³⁺	NdAl ₃ (BO ₃) ₄	300	317
1.06	Nd ³⁺	YAl ₃ (BO ₃) ₄	300	553
1.06	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	300	490,492,554-556
1.06	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	~120	490,492
1.060	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂ :Cr	300	557
1.060	Nd ³⁺	BaF ₂	77	463
1.060	Yb ³⁺	LiNbO ₃	300	999
1.060	Nd ³⁺	Ca ₄ GdO(BO ₃) ₃	300	1033
1.0600	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	300	490,492
1.0601	Nd ³⁺	CaWO ₄	77	437
1.0601	Nd ³⁺	GdGaGe ₂ O ₇	300	467,472
1.06025	Nd ³⁺	Lu ₃ Ga ₅ O ₁₂	77	505
1.0603	Nd ³⁺	Y ₃ Ga ₅ O ₁₂	300	505,560
1.0603	Nd ³⁺	Gd ₂ (WO ₄) ₃	300	562
1.0603–1.0632	Nd ³⁺	CaF ₂ -YF ₃	95–300	137
1.0604	Nd ³⁺	HfO ₂ -Y ₂ O ₃	300	563,564
1.0604	Nd ³⁺	NaLuGeO ₄	300	539,540,985
1.06045	Nd ³⁺	Gd ₃ Sc ₂ Ga ₃ O ₁₂	77	477
1.0605	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	77	267
1.0605	Nd ³⁺	Ca ₃ (Nb,Ga) ₂ Ga ₃ O ₁₂	110	439,458
1.0605	Nd ³⁺	SrF ₂ -ScF ₃	300	446
1.0606	Nd ³⁺	Gd ₂ (MoO ₄) ₃	300	568,569
1.0606	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	300	505
1.0607	Nd ³⁺	SrWO ₄	77	291
1.0607	Nd ³⁺	Sr ₃ Ca ₂ (PO ₄) ₃	300	499
1.0607	Nd ³⁺	CaF ₂ -ScF ₃	300	374
1.0608	Nd ³⁺	(Y,Lu) ₃ Al ₅ O ₁₂	77	597
1.0608	Nd ³⁺	ZrO ₂ -Y ₂ O ₃	300	563
1.0608	Nd ³⁺	Nd ₃ Ga ₅ O ₁₂	300	563
1.0608	Nd ³⁺	NaGaGe ₂ O ₇	300	470
1.0609	Nd ³⁺	Lu ₃ Ga ₅ O ₁₂	300	505
1.0609	Nd ³⁺	Ca ₂ Ga ₂ SiO ₇	77	439,536,1002

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.0609	Nd ³⁺	NaYGeO ₄	300	576,577
~1.061	Nd ³⁺	CaLa(SiO ₄) ₃ O	300	1007
1.061	Nd ³⁺	Ca ₂ Al ₂ SiO ₇	300	314
1.061	Nd ³⁺	BaGd ₂ (MoO ₄) ₄	300	584
1.061	Nd ³⁺	CaMoO ₄	300	291,474,479
1.061	Nd ³⁺	Gd ₃ Sc ₂ Ga ₃ O ₁₂ :Cr	300	531,536,542,581, 583,645,646,650, 653,659,730,732
1.061	Nd ³⁺	CaLa ₄ (SiO ₄) ₃ O	300	497,586,590,608, 644
1.0610	Nd ³⁺	Ca ₂ Ga ₂ SiO ₇	300	439,544-546,1002
1.0610	Nd ³⁺	7La ₂ O ₃ -9SiO ₂	300	466
1.0610-1.0627	Nd ³⁺	Y ₃ Al ₅ O ₁₂	77-600	137
1.0611	Nd ³⁺	SrMoO ₄	77	291,479
1.0612	Nd ³⁺	Y ₃ Al ₅ O ₁₂	77	591,592
1.0612	Nd ³⁺	Ca(NbO ₃) ₂	77	588
1.0612	Nd ³⁺	Gd ₃ Sc ₂ Ga ₃ O ₁₂	300	477
1.0612	Nd ³⁺	CaLa ₄ (SiO ₄) ₃ O	300	590
1.0612	Nd ³⁺	Ca ₃ (Nb,Ga) ₂ Ga ₃ O ₁₂	300	439,506,546
1.0613	Nd ³⁺	Ca ₄ La(PO ₄) ₃ O	300	497
1.0613	Nd ³⁺	Ba ₂ NaNb ₅ O ₁₅	300	595
1.0613	Nd ³⁺	Gd ₃ Sc ₂ Ga ₃ O ₁₂	300	596
1.0614	Nd ³⁺	Y ₃ Ga ₅ O ₁₂	77	435
1.0615	Nd ³⁺	Ca(NbO ₃) ₂	77, 300	588
1.0615	Nd ³⁺	Ca(NbO ₃) ₂	300	598,600
1.0615	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	407
1.0615	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	~120	490,492
1.0615	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	505
1.0615	Nd ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂	300	427
1.0615	Nd ³⁺	Ba _{0.25} Mg _{2.75} Y ₂ Ge ₃ O ₁₂	300	603
1.0615	Nd ³⁺	HfO ₂ -Y ₂ O ₃	110	439,546
1.0615	Nd ³⁺	NaGdGeO ₄	300	539,604,605,985
1.0615	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	414
1.0615-1.0625	Nd ³⁺	Ca(NbO ₃) ₂	300-650	994
1.0618	Nd ³⁺	Sr ₂ Ca ₃ (PO ₄) ₃	300	499
1.0618	Nd ³⁺	SrAl ₁₂ O ₁₉	300	313
1.0618	Nd ³⁺	CaF ₂ -ScF ₃	300	374
1.0618	Nd ³⁺	LaNbO ₄	300	611

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.062	Nd ³⁺	Ca _{0.25} Ba _{0.75} (NbO ₃) ₂	295	291
1.062	Nd ³⁺	LaSc ₃ (BO ₃) ₄	300	612
1.0620	Nd ³⁺	Gd ₃ Sc ₂ Al ₃ O ₁₂	300	527
1.0620	Nd ³⁺	Lu ₃ Sc ₂ Al ₃ O ₁₂	300	460
1.0621	Nd ³⁺	SrAl ₁₂ O ₁₉	300	615
1.0621	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	300	490,492
1.0622	Nd ³⁺	Y ₃ Sc ₂ Al ₃ O ₁₂	300	476,504,609
1.0623–1.10585	Nd ³⁺	CaF ₂ -SrF ₂ -BaF ₂ -YF ₃ -LaF ₃	300	438
1.0623	Nd ³⁺	Lu ₃ Ga ₅ O ₁₂	300	505
1.0623	Nd ³⁺	CaF ₂ -LuF ₃	300	425
1.0623–1.0628	Nd ³⁺	CaF ₂	560–300	137
1.0624	Nd ³⁺	LaNbO ₄	300	619
1.0625	Nd ³⁺	Y ₃ Ga ₅ O ₁₂	300	490,491
1.0625	Nd ³⁺	YVO ₄	300	620
1.0626	Nd ³⁺	Ca(NbO ₃) ₂	77	588
1.06265	Nd ³⁺	SrWO ₄	77	57
1.0627	Nd ³⁺	SrAl ₄ O ₇	77	473
1.0627	Nd ³⁺	SrMoO ₄	77	291,497
1.0627	Nd ³⁺	SrWO ₄	77	291
1.0628	Nd ³⁺	SrWO ₄	300	57
1.0629	Nd ³⁺	Ca ₅ (PO ₄) ₃ F	300	487,499
1.0629	Nd ³⁺	α -NaCaYF ₆	300	379,504
1.0629	Nd ³⁺	Bi ₄ Si ₃ O ₁₂	77,300	625
1.0629–1.0656	Nd ³⁺	CdF ₂ -YF ₃	600–300	626,627
1.063	Nd ³⁺	SrWO ₄	295	291,373
1.063	Nd ³⁺	Na ₅ (Nd,La)(WO ₄) ₄	300	373,628
1.063	Nd ³⁺	NdAl ₃ (BO ₃) ₄	300	641-643
1.063	Nd ³⁺	(La,Nd)P ₅ O ₁₄	300	621,634-640
1.063	Nd ³⁺	NdAl ₃ (BO ₃) ₄	300	630,631
1.0630	Nd ³⁺	Ca ₅ (PO ₄) ₃ F	300	632,633
1.0632	Nd ³⁺	CaF ₂ -YF ₃ -NdF ₃	300	238
1.0632	Nd ³⁺	CaF ₂ -YF ₃	300	308,309,439
1.0632–1.0642	Nd ³⁺	LaF ₃	400–700	137
1.0633	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	77	519
1.0633–1.0653	Nd ³⁺	α -NaCaCeF ₆	920–300	137

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.06335–1.0638	Nd ³⁺	LaF ₃	300–650	137,985
1.0634	Nd ³⁺	CaWO ₄	77	137
1.0634	Nd ³⁺	YVO ₄	300	778
1.0635	Nd ³⁺	LaF ₃ -SrF ₂	300	362
1.0635	Nd ³⁺	NdAl ₃ (BO ₃) ₄	300	630,652
1.0635	Nd ³⁺	NaLa(WO ₄) ₂	300	654
1.0635	Nd ³⁺	(Nd,Gd)Al ₃ (BO ₃) ₄	300	405,640,656,658
1.0635	Nd ³⁺	Bi ₄ (Si,Ge) ₃ O ₁₂	300	356
1.0635	Nd ³⁺	CaF ₂ -LuF ₃	300	425
1.0636	Nd ³⁺	(Y,Lu) ₃ Al ₅ O ₁₂	77	597
1.0636	Nd ³⁺	SrF ₂ -CeF ₃	110	439
1.0637–1.0670	Nd ³⁺	Y ₃ Al ₅ O ₁₂	170–900	137
1.06375–1.0672	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	120–900	267
1.0638	Nd ³⁺	Bi ₄ Ge ₃ O ₁₂	77	291
1.0638	Nd ³⁺	CeF ₃	300	662,663
1.0638	Nd ³⁺	CaAl ₄ O ₇	300	510
1.0638	Nd ³⁺	NaBi(WO ₄) ₂	300	665
1.0638	Nd ³⁺	NdP ₅ O ₁₄	300	394
1.0638	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	300	510
1.0638	Nd ³⁺	La ₃ Ga _{5.5} Nb _{0.5} O ₁₄	77	667,668
1.0638–1.0644	Nd ³⁺	(Y,Ce) ₃ Al ₅ O ₁₂	300	669
1.0639	Nd ³⁺	CeF ₃	77	662,663
1.0639	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	300	675
1.064	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	676-694
1.064	Nd ³⁺	Y ₃ Al ₅ O ₁₂ :Fe	300	345
1.064	Nd ³⁺	Y ₃ Al ₅ O ₁₂ :Ti	300	670
1.064	Nd ³⁺	Y ₃ Al ₅ O ₁₂ :Cr,Ce	300	671
1.064	Nd ³⁺	Y ₃ Al ₅ O ₁₂ :Ho	300	673
1.064	Nd ³⁺	Y ₃ Al ₅ O ₁₂ :Er	300	672
1.064	Nd ³⁺	YVO ₄	300	684
1.064	Nd ³⁺	LaF ₃	300	326
1.064–1.065	Nd ³⁺	SrGdGa ₃ O ₇	31	247
1.0640	Nd ³⁺	SrMoO ₄	77	291,497
1.0640	Nd ³⁺	La ₃ Ga ₅ SiO ₁₄	300	439,476,546,667, 695-698,1000
1.0640–1.0657	Nd ³⁺	CaF ₂ -CeF ₃	700–300	137
1.06405–1.0654	Nd ³⁺	YAlO ₃	77–500	626,702

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.0641	Nd ³⁺	Y ₃ Al ₅ O ₁₂ :Cr	300	592
1.0641	Nd ³⁺	YVO ₄	300	620
1.0641	Nd ³⁺	La ₃ Ga _{5.5} Ta _{0.5} O ₁₄	300	705,1000
1.06415	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	25,407-411, 492,610,984
1.0642	Nd ³⁺	(Y,Lu) ₃ Al ₅ O ₁₂	295	597
1.0642	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	300	519
1.0642	Nd ³⁺	NaBi(WO ₄) ₂	300	665
1.06425	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	267,610
1.06425	Nd ³⁺	Bi ₄ Ge ₃ O ₁₂	77	291,661
1.0643	Nd ³⁺	SrMoO ₄	295	291,497
1.0644	Nd ³⁺	YAlO ₃	300	712
1.0644	Nd ³⁺	Y ₂ SiO ₅	77	713
1.0644	Nd ³⁺	Bi ₄ Ge ₃ O ₁₂	300	291,497
1.0644	Nd ³⁺	YAlO ₃	300	712
1.0645	Nd ³⁺	CaF ₂ -LaF ₃	300	427
1.0645	Nd ³⁺	KLa(MoO ₄) ₂	110	439
1.0645	Nd ³⁺	La ₃ Ga _{5.5} Nb _{0.5} O ₁₄	300	668,1000
1.0645	Nd ³⁺	La ₃ Ga ₅ SiO ₁₄	300	695,697,698
1.0645	Nd ³⁺	YAlO ₃	300	716-718,729
1.0645	Nd ³⁺	YAlO ₃ :Cr	295	715
1.0646	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	375
1.0646	Nd ³⁺	KLa(MoO ₄) ₂	300	361
1.0647	Nd ³⁺	CeCl ₃	300	720,721
1.0648	Nd ³⁺	CaF ₂	50	301,302
1.0648	Nd ³⁺	YVO ₄	300	620
1.0648	Nd ³⁺	Ca ₃ (Nb,Ga) ₂ Ga ₃ O ₁₂	110	439,540
1.0649	Nd ³⁺	CaWO ₄	77	137
1.0649	Nd ³⁺	CaY ₂ Mg ₂ Ge ₃ O ₁₂	300	494
1.065	Nd ³⁺	GdVO ₄	300	725
1.065	Nd ³⁺	(Nd,Gd)Al ₃ (BO ₃) ₄	300	405,640,648,656, 658,729-734
1.065	Nd ³⁺	Sr ₅ (VO ₄) ₃ Cl	300	728
1.065	Nd ³⁺	Sr ₅ (VO ₄) ₃ F	300	727
1.0650	Nd ³⁺	CaWO ₄	77	735
1.0650	Nd ³⁺	La ₃ Ga ₅ GeO ₁₄	300	704,736

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.0650	Nd ³⁺	NaLa(MoO ₄) ₂	110	439
1.0650	Nd ³⁺	RbNd(WO ₄) ₂	300	737
1.0652	Nd ³⁺	CaWO ₄	300	483-486
1.0652	Nd ³⁺	SrMoO ₄	77	291,497
1.0652	Nd ³⁺	CdF ₂ -LuF ₃	300	742
1.0652–1.0659	Nd ³⁺	YAlO ₃	310–500	626,702
1.0653–1.0633	Nd ³⁺	α -NaCaCeF ₆	300–920	137
1.0653	Nd ³⁺	NaLa(MoO ₄) ₂	300	532-534
1.0653–1.0665	Nd ³⁺	NaLa(MoO ₄) ₂	300–750	137
1.0654	Nd ³⁺	CaF ₂ -GdF ₃	300	427
1.0654	Nd ³⁺	NdGaGe ₂ O ₇	300	470
1.0656	Nd ³⁺	CdF ₂ -YF ₃	300	626,627
1.0657–1.0640	Nd ³⁺	CaF ₂ -CeF ₃	300–700	137
1.0657	Nd ³⁺	CaF ₂	300	541
1.0658	Nd ³⁺	LiLa(MoO ₄) ₂	300	496
1.0658	Nd ³⁺	CsNd(MoO ₄) ₂	300	737
1.06585	Nd ³⁺	CaAl ₄ O ₇	77	510
1.0659	Nd ³⁺	GdGaGe ₂ O ₇	300	467,472
1.066	Nd ³⁺	Nd(Ga,Cr) ₃ (BO ₃) ₄	300	631
1.066	Nd ³⁺	K ₅ Nd(MoO ₄) ₄	300	758
1.066	Nd ₃ ⁺	K ₅ Bi(MoO ₄) ₄	300	758
1.0661	Nd ³⁺	CaF ₂	300	300
1.0662	Pr ³⁺	Ca(NbO ₃) ₂	~110	73
1.0663	Nd ³⁺	NaGd(MoO ₄) ₂	110	439
1.0663	Nd ³⁺	NaY(MoO ₄) ₂	110	439
1.0664	Pr ³⁺	Ca(NbO ₃) ₂	300	73
1.0664–1.0672	Nd ³⁺	YVO ₄	300–690	626,628
~1.0665	Nd ³⁺	CdF ₂ -LaF ₃	300	627
1.0666	Nd ³⁺	CdF ₂	300	763
1.0667	Nd ³⁺	CdF ₂ -CeF ₃	300	763
1.0667	Nd ³⁺	NaGd(MoO ₄) ₂	300	439,699
1.0668	Nd ³⁺	CdF ₂ -LaF ₃	300	381
1.0669	Nd ³⁺	KY(MoO ₄) ₂	300	765,766
1.067	Nd ³⁺	Ca ₃ (VO ₄) ₂	300	767
1.067	Nd ³⁺	LaF ₃	77	291-293
1.0670	Nd ³⁺	CdF ₂ -LaF ₃	≤200	380

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.0670	Nd ³⁺	La ₃ Ga ₅ SiO ₁₄	300	439,476,667, 695-698,1000
1.0671	Nd ³⁺	LuAlO ₃	77	74
1.0671	Nd ³⁺	CaF ₂ -YF ₃	110	439
1.0672	Nd ³⁺	CaY ₄ (SiO ₄) ₃ O	300	497
1.0672	Nd ³⁺	CdF ₂ -GdF ₃	300	439,742
1.0672	Nd ³⁺	KGd(WO ₄) ₂	300	76,117,136,139, 536,610
1.0672	Nd ³⁺	La ₃ Ga ₅ SiO ₁₄	300	695,697,698
1.0673	Nd ³⁺	CaMoO ₄	77, 300	291,474,479
1.0673	Nd ³⁺	La ₃ Ga ₅ SiO ₁₄	300	695,697,698
1.0674	Nd ³⁺	NaY(MoO ₄) ₂	300	439,699
1.0675	Nd ³⁺	LuAlO ₃	300	74
1.0675	Nd ³⁺	Na ₂ Nd ₂ Pb ₆ (PO ₄) ₆ Cl ₂	300	520,521
1.0675	Nd ³⁺	La ₃ Ga ₅ GeO ₁₄	77	1000
1.0675	Nd ³⁺	La ₃ Ga ₅ SiO ₁₄	77	695,697
1.0675	Nd ³⁺	Nd ₃ Ga ₅ SiO ₁₄	300	695,697,698
1.0675	Nd ³⁺	Nd ₃ Ga ₅ GeO ₁₄	300	667,736
1.0676	Nd ³⁺	CdF ₂ -GdF ₃	110	439
1.068	Nd ³⁺	Na ₂ Nd ₂ Pb ₆ (PO ₄) ₆ Cl ₂	300	520,521
1.0680	Nd ³⁺	Nd ₃ Ga ₅ GeO ₁₄	300	667,736
1.0682	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	116
1.0687–1.0690	Nd ³⁺	KY(WO ₄) ₂	77–600	250-252,984
1.0688	Nd ³⁺	Ca ₃ Ga ₂ SiO ₇	300	1016
1.0688	Nd ³⁺	Ca ₂ Ga ₂ Ge ₄ O ₁₄	300	188,667,1000
1.0688	Nd ³⁺	KY(WO ₄) ₂	300	250-252
1.0688	Nd ³⁺	Sr ₃ Ga ₂ Ge ₄ O ₁₄	77	188,667
1.0689	Nd ³⁺	GdAlO ₃	77	439,546
1.0689	Nd ³⁺	NdGaGe ₂ O ₇	300	467,470
1.069	Nd ³⁺	YVO ₄	~90	987
1.0690	Nd ³⁺	GdAlO ₃	300	439,546
1.0690	Nd ³⁺	Ca ₃ Ga ₂ Ge ₄ O ₁₄	300	118,667
1.0690	Nd ³⁺	LaSr ₂ Ga ₁₁ O ₂₀	110	234,439,546
1.0694	Nd ³⁺	CdF ₂ -GdF ₃	110	439
1.0694	Nd ³⁺	Sr ₃ Ga ₂ Ge ₄ O ₁₄	300	188,667,1000
1.0698	Nd ³⁺	La ₂ Be ₂ O ₅	300	254,255,260, 270,274,314

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.070	Nd ³⁺	La ₂ Be ₂ O ₅	300	299
1.0700	Nd ³⁺	LaBGeO ₅		330
1.0701	Nd ³⁺	Gd ₂ (MoO ₄) ₃	300	568,569
1.0701–1.0706	Nd ³⁺	KLu(WO ₄) ₂	77–600	257,610
1.0706	Nd ³⁺	KY(WO ₄) ₂	300	205
1.0706	Nd ³⁺	LaSr ₂ Ga ₁₁ O ₂₀	300	234,439,546
1.07–1.16	V ²⁺	MgF ₂	80	261,303–305
1.0710	Nd ³⁺	Y ₂ SiO ₅	77	320
1.0711	Nd ³⁺	Y ₂ SiO ₅	300	466
1.0714	Nd ³⁺	KLu(WO ₄) ₂	300	257
1.0714–1.0716	Nd ³⁺	KLu(WO ₄) ₂	550–77	272
1.0715	Nd ³⁺	Y ₂ SiO ₅	300	320
1.0716–1.0721	Nd ³⁺	KLu(WO ₄) ₂	550–77	257
1.0720	Nd ³⁺	CaSc ₂ O ₄	300	323
1.0721	Nd ³⁺	KLu(WO ₄) ₂	300	211
1.0725	Nd ³⁺	LaSr ₂ Ga ₁₁ O ₂₀	110	234,439,546
1.07255–1.0730	Nd ³⁺	YAlO ₃	77–490	626,702
1.0726	Nd ³⁺	YAlO ₃	300	495
1.0726	Nd ³⁺	(Y,Lu) ₃ Al ₅ O ₁₂	77	597
1.0729	Nd ³⁺	YAlO ₃	300	712,717,718
1.073	Nd ³⁺	Y ₂ O ₃	77	325,593
1.0730	Nd ³⁺	CaSc ₂ O ₄	77	323
1.0737	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	407,414
~1.074	Nd ³⁺	Y ₂ O ₃ -ThO ₂ -Nd ₂ O ₃	300	781
1.074	Nd ³⁺	SrAl ₁₂ O ₁₉	300	313
1.0740	Nd ³⁺	Y ₂ SiO ₅	77	713
1.0741	Nd ³⁺	Gd ₂ O ₃	300	372
1.0741	Nd ³⁺	Y ₂ SiO ₅	300	466
1.0742	Nd ³⁺	Y ₂ SiO ₅	300	320,360
~1.0746	Nd ³⁺	Y ₂ O ₃	300	325,593
1.0746	Nd ³⁺	LaSr ₂ Ga ₁₁ O ₂₀	110	234,439,546
1.075	Nd ³⁺	La ₂ O ₂ S	300	371
1.0755	Nd ³⁺	CaSc ₂ O ₄	77	323
1.0757	Nd ³⁺	Sr ₃ Ga ₂ Ge ₄ O ₁₄	300	188,667
1.0759	Nd ³⁺	GdAlO ₃	77	213,214
1.0759	Nd ³⁺	LuAlO ₃	300	75
1.0760	Nd ³⁺	GdAlO ₃	300	213,214

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.07655	Nd ³⁺	CaAl ₄ O ₇	77	510
1.0770	Nd ³⁺	YScO ₃	77	363
1.0772	Nd ³⁺	CaAl ₄ O ₇	77	510
1.0774	Nd ³⁺	YScO ₃	130	439
1.0775–1.0845	Nd ³⁺	CaYAlO ₄	300	287
1.0776	Nd ³⁺	Gd ₂ O ₃	77	372
1.0778	Nd ³⁺	LaSr ₂ Ga ₁₁ O ₂₀	110	234,439,546
1.078	Nd ³⁺	Y ₂ O ₃	77	325,593
1.0780	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	375
1.0780	Nd ³⁺	Ca ₂ Ga ₂ SiO ₇	77	439,544-546,1002
1.0780–1.086	Nd ³⁺	LaMgAl ₁₁ O ₁₉	300	431
1.0781	Nd ³⁺	Y ₂ SiO ₅	77	320
1.0782	Nd ³⁺	Y ₂ SiO ₅	300	320,466
1.0782–1.0787	Nd ³⁺	LiNbO ₃	590–450	626
1.0782–1.0815	Nd ³⁺	YAlO ₃	300	718
1.0785	Nd ³⁺	LuScO ₃	300	363
1.0785	Nd ³⁺	La ₂ Be ₂ O ₅	77	270
1.0786	Nd ³⁺	CaAl ₄ O ₇	300	510
1.0788	Nd ³⁺	Ca ₂ Ga ₂ SiO ₇	300	544-546,1002
1.0789	Nd ³⁺	Gd ₂ O ₃	77, 300	372
1.0789	Nd ³⁺	Pb ₅ Ge ₃ O ₁₁	77	417,418
1.079	Nd ³⁺	La ₂ O ₃	77	296
1.079	Nd ³⁺	La ₂ Be ₂ O ₅	300	254,255,299,416
1.0790	Nd ³⁺	La ₂ Be ₂ O ₅	300	270
1.0790	Nd ³⁺	Lu ₂ SiO ₅	300	466
1.07925	Nd ³⁺	Lu ₂ SiO ₅	300	420
1.0795	Nd ³⁺	YAlO ₃	300	356,377,423,424, 437,441,442,481, 716-718,995
1.0795–1.0802	Nd ³⁺	YAlO ₃	77–600	620,702
1.0796	Nd ³⁺	YAlO ₃	300	712
1.0796–1.0803	Nd ³⁺	YAlO ₃	600-700	718
1.0799	Nd ³⁺	Pb ₅ Ge ₃ O ₁₁	77	417,418
1.08	Nd ³⁺	Y ₂ O ₃	300	427
1.0804	Nd ³⁺	LaAlO ₃	300	213
1.0806	Nd ³⁺	CaYAlO ₄	300	422

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.0812	Nd ³⁺	LaMgAl ₁₁ O ₁₉	77	439,482,546
1.0812–4	Nd ³⁺	Sc ₂ SiO ₅	300	453,466
1.08145	Nd ³⁺	Sc ₂ SiO ₅	300	420,466
1.0817	Nd ³⁺	LaMgAl ₁₁ O ₁₉	300	439,482,546
1.082	Nd ³⁺	LaMgAl ₁₁ O ₁₉	300	313
1.082–1.084	Nd ³⁺	LaMgAl ₁₁ O ₁₉	300	444
1.0828	Nd ³⁺	SrAl ₄ O ₇	300	473
1.0829–1.0859	Nd ³⁺	LiNbO ₃	300	988,996
1.083	Nd ³⁺	YAlO ₃	300	666
1.0831	Nd ³⁺	LuAlO ₃	120	74
1.0832	Nd ₃ ⁺	LuAlO ₃	300	74
1.0832–1.0855	Nd ³⁺	YAlO ₃	300	666,718
1.0837	Nd ³⁺	YScO ₃	130	439
1.0840	Nd ³⁺	LiNbO ₃	77	457
1.0840	Nd ³⁺	GdScO ₃	200	459
1.0843	Nd ³⁺	YScO ₃	300	363,439
1.0845	Nd ³⁺	YAlO ₃	300	718
1.0846	Nd ³⁺	LiNbO ₃	300	383,449,626
1.0847	Nd ³⁺	YAlO ₃	530	626,702
1.085	Nd ³⁺	LiNbO ₃ :Mg	300	36,471,782
1.08515	Nd ³⁺	GdScO ₃	300	363
1.0867	Nd ³⁺	CaSc ₂ O ₄	77	323
1.0868	Nd ³⁺	CaSc ₂ O ₄	300	323
~1.0885	Nd ³⁺	CaF ₂ -CeO ₂	300	523
1.0885–1.0889	Nd ³⁺	CaF ₂	300–420	137,344
1.0909	Nd ³⁺	YAlO ₃	300	717,718
1.0913	Nd ³⁺	YAlO ₃	530	607,702
1.0921	Nd ³⁺	YAlO ₃	300	718
1.0922–1.0933	Nd ³⁺	LiNbO ₃	620–300	994
1.093	Nd ³⁺	LiNbO ₃	300	36,471,480,503
1.0933	Nd ³⁺	LiNbO ₃	300	348,383,449
~1.094	Nd ³⁺	LiNbO ₃ :MgO	300	1030
1.0989	Nd ³⁺	YAlO ₃	300	717,718
1.0991	Nd ³⁺	YAlO ₃	500	607,702
1.1054	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	414
1.110	Yb ³⁺	Ca ₄ Sr(PO ₄) ₃ F	300	1034
1.1119	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	414

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.1158	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	414
1.116	Tm ²⁺	CaF ₂	4.2	524,525
1.1213	V ²⁺	MgF ₂	77	488
1.1225	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	414
1.167–1.345	Cr ⁴⁺	Mg ₂ SiO ₄	300	507,706-709
1.18–1.29	Cr ⁴⁺	Y ₂ SiO ₅	77	508
1.1810	Mn ⁵⁺	Ba ₃ (VO ₄) ₂	300	509
1.190	Ho ³⁺	BaYb ₂ F ₈	300	469
1.2–1.32	Cr ⁴⁺	Mg ₂ SiO ₄	77	514
1.2085	Ho ³⁺	Gd ₃ Ga ₅ O ₁₂	~110	722
1.2155	Ho ³⁺	Y ₃ Al ₅ O ₁₂	110	993
1.2160	Ho ³⁺	Lu ₃ Al ₅ O ₁₂	110	993
1.2195	Er ³⁺	LiYF ₄	116, 300	222,231
1.2196	Er ³⁺	LiLuF ₄	110	32
1.2198	Ho ³⁺	YAlO ₃	110	241
1.228	Er ³⁺	LiErF ₄	110	233
1.2290	Er ³⁺	LiYF ₄	110	502
1.2292	Er ³⁺	LiErF ₄	90–102	223
1.2292	Er ³⁺	LiLuF ₄	110	32
1.2294	Er ³⁺	LiYF ₄	120, 300	224
1.2295	Er ³⁺	LiLuF ₄	300	32,33
1.2308	Er ³⁺	LiYF ₄	~110,300	226
1.2312	Er ³⁺	BaEr ₂ F ₈	100–112	232
1.2320	Er ³⁺	BaEr ₂ F ₈	110	215
1.234	Er ³⁺	LiYF ₄ :Yb	300	734
1.2342	Er ³⁺	(Y,Er)AlO ₃	110	190
1.236–1.300	Cr ⁴⁺	Mg ₂ SiO ₄	300	1032
1.2390	Er ³⁺	(Y,Er)AlO ₃	110	190
1.2392	Er ³⁺	(Y,Er)AlO ₃	300	190
1.24–1.33	V ²⁺	CsCaF ₃	80	582
1.244	Cr ⁴⁺	Mg ₂ SiO ₄	300	552,558,559
1.245	Er ³⁺	Y ₃ Al ₅ O ₁₂	77	237
1.26	Er ³⁺	CaF ₂	77	614
1.26	Er ³⁺	BaYb ₂ F ₈	300	587
1.2805	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	110	519,571

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.3	Cr^{4+}	Y_2SiO_5	300	567
1.3	Nd^{3+}	$\text{KNdP}_4\text{O}_{12}$	300	317
1.3	Nd^{3+}	$\text{NdAl}_3(\text{BO}_3)_4$	330	317
1.302	Nd^{3+}	KYF_4	300	573
[1.304–1.372]	Nd^{3+}	$(\text{La},\text{Nd})\text{P}_5\text{O}_{14}$	300	306,566
1.3065	Nd^{3+}	$\text{SrAl}_{12}\text{O}_{19}$	300	478,324
1.307	Nd^{3+}	KYF_4	300	573
1.3070	Nd^{3+}	$5\text{NaF}\cdot 9\text{YF}_3$	300	537
1.3077	Nd^{3+}	$\text{Gd}_3\text{Ga}_5\text{O}_{12}$	77	490,492
1.309–1.628	Cr^{4+}	$\text{Y}_3\text{Sc}_x\text{Al}_{5-x}\text{O}_{12}$ ($x=0\text{--}1.7$)	300	572
1.311–1.334	Nd^{3+}	$\text{NaNdP}_4\text{O}_{12}$	300	307
1.3125	Nd^{3+}	LaF_3	77	537
1.3130	Nd^{3+}	CeF_3	77	538
1.313	Nd^{3+}	LiYF_4	300	32,33,314
1.3133	Nd^{3+}	LiLuF_4	300	32,33
1.3144	Ni^{2+}	MgO	77	535
1.3150	Nd^{3+}	$\text{Ca}_3\text{Ga}_2\text{Ge}_3\text{O}_{12}$	300	519
1.316	Ni^{2+}	MgO	82	662
1.316–1.340	Nd^{3+}	$\text{LiNdP}_4\text{O}_{12}$	300	307
1.3160	Nd^{3+}	$\text{SrF}_2\text{--LaF}_3$	77	537
1.3165	Nd^{3+}	$\text{CdF}_2\text{--YF}_3$	77	538
1.3165	Nd^{3+}	$\alpha\text{--NaCaCeF}_6$	77	538
1.317	Nd^{3+}	$\text{Li}(\text{La},\text{Nd})\text{P}_4\text{O}_{12}$	300	105,108,109,112, 113,350,353,354, 382,576
1.317	Nd^{3+}	$\text{LiNdP}_4\text{O}_{12}$	300	306,560,561
1.3170	Nd^{3+}	CeF_3	300	538
1.3170	Nd^{3+}	$\text{LaF}_3\text{--SrF}_2$	77	549
1.3170	Nd^{3+}	BaY_2F_8	77	366
1.3172	Nd^{3+}	LiLuF_4	110	519
1.3175	Nd^{3+}	BaF_2	300	541
1.318	Ni^{2+}	MgO	80	261
1.318	Nd^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	346,570,779
1.318	Nd^{3+}	BaY_2F_8	300	366
1.3185	Nd^{3+}	$\text{CaF}_2\text{--GdF}_3$	300	434
1.3185	Nd^{3+}	$\text{BaF}_2\text{--LaF}_3$	300	602
1.3185	Nd^{3+}	KY_3F_{10}	300	461

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.3187	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	594,599
1.3188	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	375
1.319	Nd ³⁺	LiNdP ₄ O ₁₂	300	317,319,780
1.319	Nd ³⁺	Y ₃ Ga ₅ O ₁₂	300	613
1.319–1.325	Nd ³⁺	(Y,Nd)P ₅ O ₁₄	300	400
1.3190	Nd ³⁺	Ca ₂ Y ₅ F ₁₉	300	606
1.3190	Nd ³⁺	CaF ₂ -LaF ₃	300	434
1.3190	Nd ³⁺	CaF ₂ -CeF ₃	300	537
1.3190	Nd ³⁺	Sr ₂ Y ₅ F ₁₉	300	367
1.3190	Nd ³⁺	α -NaCaCeF ₆	300	538
1.32	Nd ³⁺	Gd ₃ Sc ₂ Ga ₃ O ₁₂ :Cr	300	565
1.32	Nd ³⁺	NdP ₅ O ₁₄	300	386
1.32	Nd ³⁺	(La,Nd)P ₅ O ₁₄	300	386
1.32	Nd ³⁺	K(Nd,Gd)P ₄ O ₁₂	300	404
1.32–1.43	Cr ⁴⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	300	433
1.32–1.53	Cr ⁴⁺	Y ₃ Al ₅ O ₁₂	300	585,589
1.320	Nd ³⁺	NaNdP ₄ O ₁₂	300	382
1.3200	Nd ³⁺	Ca ₂ Y ₅ F ₁₉	77	606
1.3200	Nd ³⁺	SrF ₂ -LuF ₃	300	427
1.3200	Nd ³⁺	BaF ₂ -YF ₃	300	413
1.3200	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	375
1.3200	Nd ³⁺	YP ₅ O ₁₄	300	601
1.3208	Nd ³⁺	LiLuF ₄	300	32,33
1.3209	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	538
1.3209	Nd ³⁺	Ba ₅ (PO ₄) ₃ F	300	1027
1.3212	Nd ³⁺	LiYF ₄	300	32,33
1.3225	Nd ³⁺	SrF ₂ -YF ₃	77	537
1.3225	Nd ³⁺	CaF ₂	300	541
1.323	Nd ³⁺	NdP ₅ O ₁₄	300	656
1.323	Nd ³⁺	(La,Nd)P ₅ O ₁₄	300	574,575
1.3235	Nd ³⁺	LaF ₃	77	537
1.3235	Nd ³⁺	SrF ₂ -LaF ₃	77	537
1.3240	Nd ³⁺	CeF ₃	77	538
1.324	Nd ³⁺	(La,Nd)P ₅ O ₁₄	300	566
1.3245	Nd ³⁺	CdF ₂ -YF ₃	300	538

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.3250	Nd ³⁺	SrF ₂ -LaF ₃	300	537
1.3250	Nd ³⁺	SrF ₂ -GdF ₃	77	421
1.3250	Nd ³⁺	SrF ₂	300	541
1.3255	Nd ³⁺	CaF ₂ -YF ₃	77	538
1.3255	Nd ³⁺	SrF ₂ -CeF ₃	300	518
1.3256	Nd ³⁺	LiYF ₄	110	32,33
1.3257	Nd ³⁺	LiLuF ₄	110	32
1.3260	Nd ³⁺	SrF ₂ -GdF ₃	300	421
1.3260	Nd ³⁺	α -NaCaYF ₆	77	538
1.3270	Nd ³⁺	CaF ₂ -YF ₃	300	538
1.3270	Nd ³⁺	BaF ₂	300	541
1.3270	Nd ³⁺	Ca ₃ (Nb,Ga) ₂ Ga ₃ O ₁₂	300	506
1.3275	Nd ³⁺	LaF ₃ -SrF ₂	77	549
1.328	Ni ²⁺	MgO	131	662
1.328	Nd ³⁺	Sr ₅ (PO ₄) ₃	300	515
1.3280	Nd ³⁺	BaF ₂ -LaF ₃	300	602
1.3285	Nd ³⁺	α -NaCaYF ₆	300	538
1.3285	Nd ³⁺	SrF ₂ -ScF ₃	300	446
1.3290	Nd ³⁺	BaF ₂ -LaF ₃	77	602
1.3298	Nd ³⁺	CsLa(WO ₄) ₂	300	241,475
1.3298	Nd ³⁺	GdGaGe ₂ O ₇	300	467,472
1.3	Nd ³⁺	NdAl ₃ (BO ₃) ₄	300	317
1.330	Nd ³⁺	CaF ₂ -LuF ₃	300	425
1.3300	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	300	618
1.3300	Nd ³⁺	SrF ₂ -YF ₃	77	537
1.3300	Nd ³⁺	SrMoO ₄	77	616
1.3300	Nd ³⁺	CdF ₂ -ScF ₃	300	360
1.3300	Nd ³⁺	NaLuGeO ₄	77	539,540
1.3303	Nd ³⁺	NdGaGe ₂ O ₇	300	467,470
1.3305	Nd ³⁺	LaF ₃	77	537
1.3305	Nd ³⁺	HfO ₂ -Y ₂ O ₃	300	563,564
1.3305	Nd ³⁺	Y ₃ Ga ₅ O ₁₂	300	490,491
1.3310	Nd ³⁺	LaF ₃	300	537
1.3310	Nd ³⁺	CeF ₃	77	538
1.3310	Nd ³⁺	CaWO ₄	77	617
1.3310	Nd ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂	300	427
1.3310	Nd ³⁺	NaLuGeO ₄	300	539,540

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.3315	Nd ³⁺	LaF ₃ -SrF ₂	300	549
1.3315	Nd ³⁺	Lu ₃ Ga ₅ O ₁₂	300	505
1.3315	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	300	593
1.3315	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	300	519
1.3317	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	300	675
1.3319	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	77	538
1.3320	Nd ³⁺	CeF ₃	300	538
1.3320	Nd ³⁺	SrF ₂ -YF ₃	77	537
1.3320	Nd ³⁺	SrAl ₄ O ₇	77	478
1.3320	Nd ³⁺	PbMoO ₄	77	655
1.3320	Nd ³⁺	ZrO ₂ -Y ₂ O ₃	300	564
1.3320	Nd ³⁺	Ca ₃ Ga ₄ O ₉	300	482
1.3325	Nd ³⁺	LaF ₃ -SrF ₂	77	549
1.3325	Nd ³⁺	SrMoO ₄	300	655
1.3325	Nd ³⁺	NaYGeO ₄	300	539,577
1.3326	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	538
1.3333	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	77	538
1.3334	Nd ³⁺	NaGdGeO ₄	300	539,604,605
1.3335	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	110	519,571
1.3338	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	375
1.3340	Nd ³⁺	CaWO ₄	300	253,549,980
1.3340	Nd ³⁺	PbMoO ₄	300	655
1.3342	Nd ³⁺	KLa(MoO ₄) ₂	300	501
1.3342	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	538
1.3342	Nd ³⁺	NaBi(WO ₄) ₂	300	665
1.3345	Pr ³⁺	BaY ₂ F ₈	110	241
1.3345	Nd ³⁺	CaWO ₄	77	253,549,660
1.3345	Nd ³⁺	SrAl ₄ O ₇	300	478
1.3345	Nd ³⁺	Ca ₅ (PO ₄) ₃ F	77	606
1.3347	Nd ³⁺	Ca ₅ (PO ₄) ₃ F	300	606
1.3347	Pr ³⁺	BaYb ₂ F ₈	110	241,623
1.3347	Nd ³⁺	SrWO ₄	300	57
1.3350	Nd ³⁺	KLa(MoO ₄) ₂	77, 300	498
1.3350	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	375
1.3354	Nd ³⁺	CaLa ₄ (SiO ₄) ₃ O	300	644

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.3355	Nd ³⁺	SrF ₂ -LaF ₃	77	537
1.3355	Nd ³⁺	NaLa(WO ₄) ₂	300	655
1.3360	Nd ³⁺	Y ₃ Sc ₂ Al ₃ O ₁₂	300	465
1.3360	Nd ³⁺	Gd ₃ Sc ₂ Al ₃ O ₁₂	300	476
1.3360	Nd ³⁺	Lu ₃ Sc ₂ Al ₃ O ₁₂	300	460
1.3360	Nd ³⁺	Y ₃ Sc ₂ Al ₃ O ₁₂	300	504
1.3360	Nd ³⁺	CdF ₂ -CeF ₃	300	763
1.3365	Nd ³⁺	Ca ₂ Ga ₂ SiO ₇	300	439,544-546
1.3365	Nd ³⁺	CdF ₂ -GaF ₃	300	742
1.3365	Nd ³⁺	CdF ₂ -LaF ₃	300	380
1.3370	Nd ³⁺	CaF ₂ -YF ₃	300	538
1.3370	Nd ³⁺	Ca(NbO ₃) ₂	77	607
1.3370	Nd ³⁺	CaWO ₄	300	253,549,980
1.3370	Nd ³⁺	Gd ₃ Ga ₅ O ₁₂	300	279,527
1.3370	Nd ³⁺	LiLa(MoO ₄) ₂	300	655
1.3372	Nd ³⁺	CaWO ₄	77	253,549,980
1.3375	Nd ³⁺	α -NaCaYF ₆	300	538
1.3375	Nd ³⁺	PbMoO ₄	77	616
1.3375	Nd ³⁺	LiLa(MoO ₄) ₂	77	655
1.3375	Nd ³⁺	Ca ₂ Ga ₂ SiO ₇	110	544-546
1.3376	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	77	602
1.338	Nd ³⁺	Y ₃ Ga ₅ O ₁₂	300	314,613
1.3380	Nd ³⁺	CaF ₂ -YF ₃	77	538
1.3380	Nd ³⁺	Ca(NbO ₃) ₂	300	607
1.3380	Nd ³⁺	NaLa(MoO ₄) ₂	77, 300	655
1.3381	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	594
1.3382	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	375
1.3385	Nd ³⁺	NaGd(MoO ₄) ₂	300	655
1.3387	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	267
1.339	Nd ³⁺	YF ₃	300	415
1.3390	Nd ³⁺	α -NaCaYF ₆	77	538
1.3390	Nd ³⁺	CaWO ₄	300	253,549,980
1.3391	Nd ³⁺	YAlO ₃	77	549,660,717
1.3393	Nd ³⁺	YAlO ₃	77	599,717
~1.34	Nd ³⁺	GdVO ₄	300	550
1.34	Nd ³⁺	YVO ₄	300	778
1.3400	Nd ³⁺	CaAl ₄ O ₇	77	478

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.3400	Nd ³⁺	LiGd(MoO ₄) ₂	77, 300	655
1.3400	Nd ³⁺	YAlO ₃	300	549,717,980
1.3407	Nd ³⁺	Bi ₄ Si ₃ O ₁₂	300	625
1.341	Nd ³⁺	NdAl ₃ (BO ₃) ₄	300	656
1.3410	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	375
1.3410	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	267
1.3410	Nd ³⁺	YAlO ₃	300	253,599,717
1.3410	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	375
1.3413	Nd ³⁺	YAlO ₃	300	712
1.3414	Nd ³⁺	YAlO ₃	300	995
1.3415	Nd ³⁺	Ca(NbO ₃) ₂	77	607
1.3415	Nd ³⁺	YVO ₄	77	537
1.3416	Nd ³⁺	YAlO ₃	300	549,660,717
1.3418	Nd ³⁺	Bi ₄ Ge ₃ O ₁₂	300	291,661
1.3420	Nd ³⁺	CaAl ₄ O ₇	300	478
1.3425	Nd ³⁺	Ca(NbO ₃) ₂	300	607
1.3425	Nd ³⁺	YVO ₄	300	537
1.3425	Nd ³⁺	PbMoO ₄	300	655
1.3425	Nd ³⁺	CdF ₂ -YF ₃	300	538
1.3430	Nd ³⁺	NaLa(MoO ₄) ₂	77	655
1.3437	Nd ³⁺	LuAlO ₃	300	74
1.3440	Nd ³⁺	SrMoO ₄	77	616,655
1.3440	Nd ³⁺	LiLa(MoO ₄) ₂	77	655
1.3440	Nd ³⁺	NaLa(MoO ₄) ₂	300	655
1.345	Nd ³⁺	NdAl ₃ (BO ₃) ₄	300	648
1.3450	Nd ³⁺	PbMoO ₄	77	655
1.3455	Nd ³⁺	LiGd(MoO ₄) ₂	77	655
1.3459	Nd ³⁺	CaWO ₄	77	253,549,660
1.3465	Pr ³⁺	LiYbF ₄	110	241
1.3468	Pr ³⁺	LiYbF ₄	110	241,246
1.3475	Nd ³⁺	CaWO ₄	300	253,549,980
1.348–1.482	Cr ⁴⁺	Ca ₂ GeO ₄	300	629
1.3482	Nd ³⁺	KLu(WO ₄) ₂	300	211,272
1.3485	Nd ³⁺	KY(MoO ₄) ₂	300	549,765
1.3493	Nd ³⁺	Ca ₃ Ga ₂ Ge ₄ O ₁₄	300	188,667

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.3499	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	77	602
1.35–1.5	Cr ⁴⁺	Y ₃ Al ₅ O ₁₂	300	981,982
1.350–1.560	Cr ⁴⁺	Y ₃ Al ₅ O ₁₂	300	647
1.3500	Nd ³⁺	CdF ₂ -LuF ₃	300	742
1.3505	Nd ³⁺	CaF ₂ -ScF ₃	300	374
1.351	Nd ³⁺	La ₂ Be ₂ O ₅	300	314,649
1.3510	Nd ³⁺	KGd(WO ₄) ₂	300	76
1.3510	Nd ³⁺	La ₂ Be ₂ O ₅	300	651
1.3510	Nd ³⁺	Sr ₃ Ga ₂ Ge ₄ O ₁₄	300	188,667
1.3512	Nd ³⁺	YAlO ₃	300	549
1.3514	Nd ³⁺	YAlO ₃	300	549,717,980
1.3515	Nd ³⁺	KY(WO ₄) ₂	77	250-252
1.3520	Nd ³⁺	CdF ₂ -GdF ₃	300	742
1.3525	Nd ³⁺	Ca ₂ Y ₅ F ₁₉	300	606
1.3525	Nd ³⁺	KY(WO ₄) ₂	300	250-252
1.3525	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	267
1.3530	Nd ³⁺	SrAl ₄ O ₇	77	478
1.3532	Nd ³⁺	Lu ₃ Al ₅ O ₁₂	300	496
1.3533	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	660
1.3533	Nd ³⁺	KLa(MoO ₄) ₂	300	501
1.3533	Nd ³⁺	KLu(WO ₄) ₂	300	257
1.354	Nd ³⁺	La ₂ Be ₂ O ₅	300	151
1.3545	Nd ³⁺	KY(WO ₄) ₂	77, 300	250-252
1.3545	Nd ³⁺	Ca ₃ Ga ₂ Ge ₃ O ₁₂	110	519
1.3550	Nd ³⁺	LiNbO ₃	300	603
1.3550	Nd ³⁺	KLu(WO ₄) ₂	300	257
1.3564	Nd ³⁺	Y ₃ Al ₅ O ₁₂	77	375
1.3565	Nd ³⁺	CaSc ₂ O ₄	300	323,504
1.3572	Nd ³⁺	Y ₃ Al ₅ O ₁₂	300	660
~1.358	Nd ³⁺	Y ₂ O ₃	300	325,593
1.3585	Nd ³⁺	CaF ₂ -YF ₃	300	538
1.3585	Nd ³⁺	Y ₂ SiO ₅	300	466
1.3585	Nd ³⁺	Lu ₂ SiO ₅	300	466
1.3595	Nd ³⁺	LaF ₃	300	537
1.3600	Nd ³⁺	CaF ₂ -YF ₃	77	538
1.3600	Nd ³⁺	α -NaCaYF ₆	300	538
1.3628	Nd ³⁺	LaSr ₂ Ga ₁₁ O ₂₀	300	234,439,564

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.3630	Nd ³⁺	KLa(MoO ₄) ₂	300	501
1.3630-2	Nd ³⁺	Sc ₂ SiO ₅	300	453,466
1.3644	Nd ³⁺	YAlO ₃	77	549,660,717
1.365	Nd ³⁺	La ₂ Be ₂ O ₅	300	663
1.3657	Nd ³⁺	KLa(MoO ₄) ₂	300	501
1.3665	Nd ³⁺	SrAl ₄ O ₇	300	478
1.3670	Nd ³⁺	LaF ₃	77	537
1.3675	Nd ³⁺	LaF ₃	300	537
1.3675	Nd ³⁺	CeF ₃	77	538
1.3675	Nd ³⁺	CaAl ₄ O ₇	77	478
1.3680	Nd ³⁺	SrAl ₄ O ₇	300	602
1.369	Ni ²⁺	MgO	153	662
1.3690	Nd ³⁺	CeF ₃	300	602
1.37	Cr ⁴⁺	CaGd ₄ (SiO ₄) ₃ O	300	701
1.37–1.51	Cr ⁴⁺	Y ₃ Al ₅ O ₁₂	300	664
1.3707	Nd ³⁺	La ₃ Ga _{5.5} Nb _{0.5} O ₁₄	300	667,668
1.3710	Nd ³⁺	CaAl ₄ O ₇	300	478
1.3730	Nd ³⁺	La ₃ Ga ₅ GeO ₁₄	300	667,668
1.3730	Nd ³⁺	La ₃ Ga ₅ SiO ₁₄	300	695,697,698
1.3730	Nd ³⁺	La ₃ Ga _{5.5} Ta _{0.5} O ₁₄	300	667,705
1.3745	Nd ³⁺	LiNbO ₃	300	383,538
1.3755	Nd ³⁺	NaLa(MoO ₄) ₂	77	655
1.3760	Nd ³⁺	LaMgAl ₁₁ O ₁₉	300	455
1.3780	Nd ³⁺	PbMoO ₄	77	655
1.3790	Nd ³⁺	SrMoO ₄	77	655
1.3806	Ho ³⁺	YAlO ₃	300	190,241
1.3840	Nd ³⁺	NaLa(MoO ₄) ₂	77	655
1.3849	Nd ³⁺	YAlO ₃	77	549
1.3865	Ho ³⁺	BaYb ₂ F ₈	110	703
1.3868	Nd ³⁺	LaBGeO ₅	300	330
1.3870	Nd ³⁺	LiNbO ₃	300	383,538
1.3870	Nd ³⁺	CaSc ₂ O ₄	77	323,504
1.3880	Nd ³⁺	CaWO ₄	77	253,549,980
1.3885	Nd ³⁺	CaWO ₄	300	549
1.390–1.475	Cr ⁴⁺	Ca ₂ GeO ₄	300	1032

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.3900	Ho^{3+}	YAlO_3	110	190,241
1.3908	Ho^{3+}	$\text{KY}(\text{WO}_4)_2$	~ 110	993
1.3918	Ho^{3+}	LiLuF_4	110	32
1.392	Ho^{3+}	LiYF_4	300	719
1.3920	Ho^{3+}	LiLuF_4	300	32
1.3950	Ho^{3+}	YAlO_3	110	190
1.3960	Ho^{3+}	LiYF_4	116, 300	167,181
1.3982	Ho^{3+}	$\text{KGd}(\text{WO}_4)_2$	110	993
1.4	Ho^{3+}	$\text{KLa}(\text{MoO}_4)_2$	110	501
1.4003	Ho^{3+}	YAlO_3	110	190
1.4026	Nd^{3+}	YAlO_3	~ 110	549
1.4028	Ho^{3+}	YAlO_3	110	993
1.4040	Ho^{3+}	$\text{Gd}_3\text{Ga}_5\text{O}_{12}$	~ 110	722
1.4058	Ho^{3+}	YAlO_3	110–300	190
1.4072	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	~ 110	993
1.4085	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}$	~ 110	993
1.409	Ni^{2+}	MgO	235	662
1.414	Ni^{2+}	MgO	235	375
1.4150	Nd^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	723
1.44	Nd^{3+}	$\text{SrGd}_4(\text{SiO}_4)_3\text{O}$	300	701
1.4440	Ni^{2+}	MgO	235	375
1.4444	Nd^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	724
1.449–1.455	Tm^{3+}	$\text{LiYF}_4\text{:Tb}$	300	700
1.46	Ni^{2+}	$\text{CaY}_2\text{Mg}_2\text{Ge}_3\text{O}_{12}$	80	261,704
1.464	Tm^{3+}	$\text{LiYF}_4\text{:Yb}$	300	80
1.48	Tm^{3+}	$\text{Gd}_3\text{Sc}_2\text{Ga}_3\text{O}_{12}$	300	710
1.482	Tm^{3+}	BaYb_2F_8	300	711,714
1.486	Ho^{3+}	LiYF_4	90	268,269
1.4862	Ho^{3+}	LiYF_4	90, 116	749,750
1.4912	Ho^{3+}	LiYF_4	190	181
1.5–2.3	Co^{2+}	MgF_2	80	114,543,704, 762,768–773
1.50	Tm^{3+}	LiYF_4	300	743
1.500	Tm^{3+}	$\text{LiYF}_4\text{:Yb}$	300	80
1.5298	Er^{3+}	CaF_2	77	674
1.530	Er^{3+}	$\text{Ca}_2\text{Al}_2\text{SiO}_7\text{:Yb}$	300	744
1.5308	Er^{3+}	CaF_2	77	674

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.532	Er ³⁺	LiNbO ₃	300	747
1.547	Er ³⁺	CaF ₂ -YF ₃	77	215,216
1.550	Er ³⁺	Ca ₂ Al ₂ SiO ₇ :Yb	300	733,744
1.5500	Er ³⁺	CaAl ₄ O ₇	77	510
1.554	Er ³⁺	SrY ₄ ((SiO ₄) ₃ O:Yb	300	426
1.5542	Er ³⁺	Er(Y,Gd)AlO ₃	77	783
1.555	Er ³⁺	Ca ₂ Al ₂ SiO ₇ :Yb,Ce	300	744
1.5554	Er ³⁺	YAlO ₃	77	783
1.5578	Er ³⁺	Bi ₄ Ge ₃ O ₁₂	77	229
1.563	Er ³⁺	LiNbO ₃	300	752
1.5646	Er ³⁺	GdAlO ₃	77	784
1.568	Tm ³⁺	LiYF ₄ :Yb	300	80
1.576	Er ³⁺	LiNbO ₃	300	752
1.5808	Tm ³⁺	BaY ₂ F ₈	300	79
1.5815	Er ³⁺	CaAl ₄ O ₇	77	510
1.59	Ni ²⁺	KMgF ₃	80	774
1.6(a)	Ni ²⁺	MnF ₂	77	535
1.61	Er ³⁺	Ca(NbO ₃) ₂	77	753
1.61–1.74	Ni ²⁺	MgF ₂	80	261,543,704,754, 771,774,775
1.6113	Er ³⁺	LaF ₃	77	810
1.612	Er ³⁺	CaWO ₄	77	757
1.617	Er ³⁺	CaF ₂	77	760
1.620	Er ³⁺	LiYF ₄	300	755
1.620	Er ³⁺	ZrO ₂ -Er ₂ O ₃	77	764
1.62–1.90	Co ²⁺	KMgF ₃	80	192
1.622-3	Er ³⁺	YAlO ₃	300	777,787
1.623	Ni ²⁺	MgF ₂	77	535,739
1.63–2.11	Co ²⁺	MgF ₂	80	754
1.632	Er ³⁺	Y ₃ Al ₅ O ₁₂	300	738
1.636	Ni ²⁺	MgF ₂	77–82	740
1.64	Er ³⁺	Y ₃ Ga ₅ O ₁₂	300	976
1.64	Er ³⁺	Y ₃ Al ₅ O ₁₂	300	756
1.643	Er ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂	300	1026
1.6437	Er ³⁺	YScO ₃ :Gd	77	783
1.644	Er ³⁺	Y ₃ Al ₅ O ₁₂	300	954

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.644	Pr ³⁺	LaCl ₃	130	761
1.6449	Er ³⁺	Y ₃ Al ₅ O ₁₂	295	741
1.6452	Er ³⁺	Y ₃ Al ₅ O ₁₂	77	651
1.6455	Er ³⁺	BaEr ₂ F ₈	110	115
1.6459	Er ³⁺	Y ₃ Al ₅ O ₁₃	295	793
1.646	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	300	766
1.6470	Er ³⁺	LiYF ₄	110	226
1.65–2.15	Co ²⁺	KZnF ₃	27	192,785,786,1003
1.6525	Er ³⁺	Lu ₃ Al ₅ O ₁₂	77	794
1.6596	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	77	237
1.66	Er ³⁺	YAlO ₃	300	788,789
1.6600	Er ³⁺	YAlO ₃ :Gd	300	783
1.6602	Er ³⁺	Y ₃ Al ₅ O ₁₂	77	651
1.6615	Er ³⁺	Yb ₃ Al ₅ O ₁₂	77	726
1.6615	Er ³⁺	CaF ₂ -ErF ₃	110	791
1.662–3	Er ³⁺	YAlO ₃	300	788,789
1.6628	Er ³⁺	(Y,Er)AlO ₃	110	788,789,792
1.6630	Er ³⁺	Lu ₃ Al ₅ O ₁₂	77	794
1.6631	Er ³⁺	(Y,Er)AlO ₃	110	788-790
1.6632	Er ³⁺	YAlO ₃	300	119,129,716,797
1.6632	Er ³⁺	ErAlO ₃	110	925
1.6640	Er ³⁺	LiYF ₄	138–300	223,231
1.6645	Er ³⁺	Bi ₄ Ge ₃ O ₁₂	77	229
1.667	Er ³⁺	(Y,Er)AlO ₃	300	777
1.6675	Er ³⁺	LuAlO ₃	~90	795
1.6682	Er ³⁺	YScO ₃ :Gd	77	783
1.6714	Er ³⁺	GdAlO ₃	77	784
1.673	Ho ³⁺	LiYF ₄	300	719
1.674–1.676	Ni ²⁺	MgF ₂	82–100	535,739
1.6776	Er ³⁺	YAlO ₃	300	797
1.696	Er ³⁺	CaF ₂	77	592
1.7036	Er ³⁺	LiYF ₄	116, 250	223,231
1.7042	Er ³⁺	LiErF ₄	110	233
1.706	Er ³⁺	(Y,Er)AlO ₃	300	777
1.7061	Er ³⁺	YAlO ₃	300	797
1.715	Er ³⁺	CaF ₂	77	592
1.7155	Er ³⁺	KGd(WO ₄) ₂	300	219,796

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.7178	Er ³⁺	KY(WO ₄) ₂	300	236
1.726	Er ³⁺	CaF ₂	77	592
1.726	Er ³⁺	(Y,Er)AlO ₃	300	777
1.7280	Er ³⁺	KLa(MoO ₄) ₂	110	501
1.7296	Er ³⁺	YAlO ₃	300	797
1.73	Er ³⁺	KLa(MoO ₄) ₂	300	501
1.730	Er ³⁺	LiYF ₄	300	808
1.731–1.756	Ni ²⁺	MgF ₂	100–192	535,739
1.7312	Er ³⁺	LiYF ₄	116, 300	224
1.732	Er ³⁺	LiErF ₄	~90	268,269
1.7320	Er ³⁺	LiYF ₄	110, 300	226
1.7322	Er ³⁺	LiErF ₄	90	223
1.7325	Er ³⁺	KGd(WO ₄) ₂	300	219,796
1.7330	Er ³⁺	KGd(WO ₄) ₂	300	809
1.7343	Er ³⁺	LiLuF ₄	110	32
1.7345	Er ³⁺	LiLuF ₄	300	32,33
1.7350	Er ³⁺	BaEr ₂ F ₈	102–112	232
1.7355	Er ³⁺	BaEr ₂ F ₈	110	115
1.7355	Er ³⁺	KY(WO ₄) ₂	300	236
1.7360	Er ³⁺	BaYb ₂ F ₈	110	115
1.7370	Er ³⁺	KLu(WO ₄) ₂	300	300
1.7372	Er ³⁺	KEr(WO ₄) ₂	300	809
1.7372	Er ³⁺	KY _{0.5} Er _{0.5} (WO ₄) ₂	300	809
1.7383	Er ³⁺	KLu(WO ₄) ₂	300	809
1.7390	Er ³⁺	KLu(WO ₄) ₂	300	809
1.7410	Er ³⁺	Ca(NbO ₃) ₂	110	57
1.75	Ni ²⁺	MgF ₂	200	806
1.750	Co ²⁺	MgF ₂	77	535,801
1.7757	Er ³⁺	Y ₃ Al ₅ O ₁₂	300	790,802
1.776	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	77–110	237
1.7762	Er ³⁺	Lu ₃ Al ₅ O ₁₂	300	790,794
1.7762	Er ³⁺	Er ₃ Al ₅ O ₁₂	110	790
1.7767	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	110	790
1.785–1.797	Ni ²⁺	MgF ₂	190–240	535,739
1.800–2.450	Co ²⁺	MgF ₂	300	799,1003

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.8035	Co^{2+}	MgF_2	77	535,801
1.821	Co^{2+}	KMgF_3	77	535,1003
1.833	Nd^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	293	807
1.85–2.14	Tm^{3+}	$\text{Y}_3\text{Sc}_2\text{Ga}_3\text{O}_{12}$	300	800
1.8529	Tm^{3+}	GdAlO_3	77	804
1.8532	Tm^{3+}	LiNbO_3	77	370
1.856	Tm^{3+}	$\text{YAlO}_3\text{:Cr}$	90	803
1.8580	Tm^{3+}	$\alpha\text{-NaCaErF}_6$	150	805
1.860	Tm^{3+}	$\text{CaF}_2\text{-ErF}_3$	77	798
1.861	Tm^{3+}	$(\text{Y,Er})\text{AlO}_3$	77	130
1.862	Tm^{3+}	$\text{Y}_3\text{Sc}_2\text{Ga}_3\text{O}_{12}$	300	979
1.865	Ni^{2+}	MnF_2	20	535
1.87–2.16	Tm^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	800
1.872	Tm^{3+}	ErAlO_3	77	819
1.88	Tm^{3+}	LiYF_4	300	811
1.880	Tm^{3+}	$(\text{Y,Er})_3\text{Al}_5\text{O}_{12}$	77	80
1.883	Tm^{3+}	YAlO_3	90	803
1.8834	Tm^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	77	278
1.884	Tm^{3+}	$(\text{Y,Er})_3\text{Al}_5\text{O}_{12}$	77	794
1.8845	Tm^{3+}	$(\text{Er,Lu})\text{AlO}_3$	77	840
1.8850	Tm^{3+}	$(\text{Er,Yb})_3\text{Al}_5\text{O}_{12}$	77	726
1.8855	Tm^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}$	77	794
1.8885	Tm^{3+}	$\alpha\text{-NaCaErF}_6$	77, 150	805
1.8890	Tm^{3+}	LiYF_4	110	812
1.894	Tm^{3+}	$\text{CaF}_2\text{:Er}$	~100	790,836,936
~1.896	Tm^{3+}	$\text{ZrO}_2\text{-Er}_2\text{O}_3$	77	764
~1.9	Tm^{3+}	$\text{CaF}_2\text{:Er}$	77	755
1.9–2.0	Tm^{3+}	$\text{Er}_3\text{Al}_5\text{O}_{12}$	77	823
1.9060	Tm^{3+}	$\text{CaMoO}_4\text{:Er}$	77	821
1.9090	Tm^{3+}	LiYF_4	110	812
1.91	Tm^{3+}	$\text{Ca}(\text{NbO}_3)_2$	77	753
1.911	Tm^{3+}	CaWO_4	77	291
1.9115	Tm^{3+}	CaMoO_4	77	821
1.915	Ni^{2+}	MnF_2	77	535
1.916	Tm^{3+}	CaWO_4	77	291,822
1.9190	Tm^{3+}	BaYb_2F_8	300	813
1.922	Ni^{2+}	MnF_2	77	535

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
1.929	Ni ²⁺	MnF ₂	85	535
1.9335	Tm ³⁺	YAlO ₃ :Cr	90	803
1.934	Tm ³⁺	Er ₂ O ₃	77	816
1.939	Ni ²⁺	MnF ₂	85	535
1.94	Tm ³⁺	YVO ₄	300	827
1.94	Tm ³⁺	CaY ₄ (SiO ₄) ₃ O	300	826
1.945–2.014	Tm ³⁺	Y ₃ Al ₅ O ₁₂ :Cr	300	828
1.96	Er ³⁺	BaYb ₂ F ₈	300	953,1004
1.965	Er ³⁺	BaYb ₂ F ₈	300	817,1004
1.9654-5	Er ³⁺	BaYb ₂ F ₈	300	548,549
1.972	Tm ³⁺	SrF ₂	77	463
1.99	Co ²⁺	MgF ₂	77	80,535
1.9925	Ho ³⁺	GdAlO ₃	90	825
1.9925	Er ³⁺	BaYb ₂ F ₈ :Tm,Yb	110	813
1.9965	Er ³⁺	BaYb ₂ F ₈	110	115
1.9975	Er ³⁺	BaEr ₂ F ₈	110	115
~2.0	Tm ³⁺	Y ₂ O ₃	300	867
~2.0	Ho ³⁺	SrY ₄ (SiO ₄) ₃ O	77	497
~2.0	Tm ³⁺	YVO ₄	77	832
2	Ho ³⁺	Y ₃ Al ₅ O ₁₂ :Tm	300	814,815,818
2.0	Ho ³⁺	Li(Y,Er)F ₄	77	841
2.0005	Er ³⁺	LiErF ₄	110	233
2.0010	Ho ³⁺	(Er,Lu)AlO ₃	77	840
2.0025	Er ³⁺	LiYbF ₄	300	813
2.0132	Tm ³⁺	Y ₃ Al ₅ O ₁₂ :Cr	77	278
2.014	Tm ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	85	278
2.014	Tm ³⁺	Y ₃ Al ₅ O ₁₂ :Cr	300	977
2.015	Tm ³⁺	Y ₃ Al ₅ O ₁₂ :Cr	300	978
2.018	Tm ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂	300	829
2.019	Tm ³⁺	Y ₃ Al ₅ O ₁₂ :Cr	300	278
2.0195	Tm ³⁺	(Er,Yb) ₃ Al ₅ O ₁₂	77	726
2.02	Tm ³⁺	Ca(NbGa) ₂ Ga ₃ O ₁₂	300	830
2.0240	Tm ³⁺	Lu ₃ Al ₅ O ₁₂	77	794
2.030	Ho ³⁺	CaF ₂ -ErF ₂	77	835
2.0312	Ho ³⁺	α -NaCaErF ₆	77	805

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
2.0318	Ho^{3+}	$\text{CaF}_2\text{-YF}_3$	77	834
2.0345	Ho^{3+}	$\alpha\text{-NaCaErF}_6$	150	805
2.0377	Ho^{3+}	$\alpha\text{-NaCaErF}_6$	77	805
2.0412	Ho^{3+}	YVO_4	77	833
2.0416	Ho^{3+}	$\text{ErVO}_4\text{:Tm}$	77	833
2.046	Ho^{3+}	CaWO_4	77	291,820
2.047	Ho^{3+}	$\text{Ca}(\text{NbO}_3)_2$	77	753
2.048–2.071	Ho^{3+}	$\text{LiYF}_4\text{:Er,Tm}$	77	842
2.049	Ho^{3+}	$\text{GdVO}_4\text{:Tm}$	300	578
2.0490–2.0559	Ho^{3+}	LiErF_4	300	843
2.0496	Ho^{3+}	$\text{SrF}_2\text{-(Y,Er)F}_3$	120, 300	844
2.05	Ho^{3+}	$\text{CaF}_2\text{-ErF}_3\text{-TmF}_3\text{-YbF}_3$	100	836,837
2.05	Co^{2+}	MgF_2	77	80,535
2.050	Ho^{3+}	$\text{NaLa}(\text{MoO}_4)_2\text{:Er}$	90	839
2.0505	Ho^{3+}	LiYF_4	300	847,1001
2.053	Ho^{3+}	$\text{SrF}_2\text{-(Y,Er)F}_3$	120, 300	844,845
2.0534	Ho^{3+}	LiYF_4	300	847
2.055	Ho^{3+}	$\text{LiLuF}_4\text{:Tm}$	300	831
2.0555	Ho^{3+}	$\text{BaY}_2\text{F}_8\text{:Er,Tm}$	20	838
2.0556	Ho^{3+}	CaMoO_4	77	821
2.0560	Ho^{3+}	BaTm_2F_8	110–230	813
2.0563	Ho^{3+}	BaYb_2F_8	295	846
2.0565	Ho^{3+}	$\text{KY}(\text{WO}_4)_2$	110	848
2.059	Ho^{3+}	CaWO_4	77	291,820
2.06	Ho^{3+}	Li(Y,Er)F_4	300	849
2.06	Ho^{3+}	LiLuF_4	300	849
2.060	Ho^{3+}	$\text{CaF}_2\text{-ErF}_3\text{-TmF}_3\text{YbF}_3$	298	836
2.060	Ho^{3+}	$\text{CaY}_4(\text{SiO}_4)_3\text{O}$	77	497
2.060	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	858
2.0610–2.0650	Ho^{3+}	LiErF_4	300	843
2.0644	Ho^{3+}	$\text{BaY}_2\text{F}_8\text{:Er,Tm}$	85	152
2.065	Ho^{3+}	BaY_2F_8	77	152
2.065	Ho^{3+}	$\text{LiYF}_4\text{:Er,Tm}$	220	787
2.065	Ho^{3+}	Li(Y,Er)F_4	220-300	787
2.065	Ho^{3+}	LiYbF_4	300	850
2.065	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	858
2.0654	Ho^{3+}	Li(Y,Er)F_4	300	853

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
2.0656	Ho^{3+}	Li(Y,Er)F_4	300	847
2.066	Ho^{3+}	$\text{LiYF}_4\text{:Er}$	77	854
2.0665	Ho^{3+}	BaYb_2F_8	110	703,848
2.067	Ho^{3+}	$\text{LiYF}_4\text{:Tm}$	300	340
2.068	Ho^{3+}	$\text{LiLuF}_4\text{:Tm}$	300	831
2.0672	Ho^{3+}	LiYF_4	~ 90	852
2.07	Ho^{3+}	LaNbO_4	~ 90	839
2.0707	Ho^{3+}	CaMoO_4	77	821
2.0715	Ho^{3+}	BaYb_2F_8	110	703,848
2.0720	Ho^{3+}	$\text{K(Y,Er)(WO}_4)_2\text{:Tm}$	110–220	855
2.0725	Ho^{3+}	LaNbO_4	110	851
2.074	Ho^{3+}	BaY_2F_8	20	838
2.074	Ho^{3+}	CaMoO_4	77	821
2.0740	Ho^{3+}	$\text{KGd(WO}_4)_2$	110	851
2.0746–2.076	Ho^{3+}	$\text{BaY}_2\text{F}_8\text{:Er,Tm}$	85	838
2.0765	Ho^{3+}	$\text{KY(WO}_4)_2$	110	848,851
2.0786	Ho^{3+}	LiNbO_3	77	370
~ 2.079	Ho^{3+}	$\text{Ca}_5(\text{PO}_4)_3\text{F}$	77	497
2.0790	Ho^{3+}	$\text{KLu(WO}_4)_2$	110	887
2.080–2.089	Ho^{3+}	$\text{Y}_3\text{Sc}_2\text{Al}_3\text{O}_{12}$	300	859
2.085	Ho^{3+}	Er_2SiO_5	77	856
2.086	Ho^{3+}	$\text{Y}_3\text{Fe}_5\text{O}_{12}$	77	857
2.086	Ho^{3+}	$\text{Y}_3\text{Ga}_5\text{O}_{12}$	77	857
2.086	Ho^{3+}	$\text{Y}_3\text{Ga}_5\text{O}_{12}\text{:Fe}$	77, >140	860
2.086	Ho^{3+}	$\text{Ho}_3\text{Ga}_5\text{O}_{12}$	77	713
2.086	Ho^{3+}	$\text{BaEr}_2\text{F}_8\text{:Tm}$	300	870-872
2.086	Ho^{3+}	$\text{Y}_3\text{Sc}_2\text{Al}_3\text{O}_{12}$	300	869
2.086	Ho^{3+}	$\text{Y}_3\text{Sc}_2\text{Ga}_3\text{O}_{12}$	300	776,869
2.0866	Ho^{3+}	$\text{BaY}_2\text{F}_8\text{:Er,Tm}$	77	838
2.087	Ho^{3+}	$\text{Bi}_4\text{Ge}_3\text{O}_{12}$	77	229
2.088	Ho^{3+}	$\text{Gd}_3\text{Sc}_y\text{Ga}_{5-y}\text{O}_{12}$	300	341,818,873
2.088	Ho^{3+}	$\text{Y}_3\text{Sc}_2\text{Ga}_3\text{O}_{12}$	300	874-876
2.0885	Ho^{3+}	$\text{Gd}_3\text{Ga}_5\text{O}_{12}$	110	722,851
2.089	Ho^{3+}	$\text{Y}_3\text{Fe}_5\text{O}_{12}$	77	857
2.089–2.102	Ho^{3+}	ErAlO_3	77	878

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
2.0895	Ho^{3+}	BaYb_2F_8	110	703,848
2.09	Ho^{3+}	$\text{Gd}_3\text{Sc}_2\text{Al}_3\text{O}_{12}$	300	861
2.090	Ho^{3+}	$(\text{Er},\text{Ho})\text{F}_3$	77	863
2.091	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Tm}$	300	776
2.0914	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	77	868
2.0917	Ho^{3+}	$(\text{Y},\text{Er})_3\text{Al}_5\text{O}_{12}$	77	278
2.092	Ho^{3+}	CaF_2	77	463
2.092	Ho^{3+}	Y_2SiO_5	~ 110	856
2.0960	Ho^{3+}	$\text{Yb}_3\text{Al}_5\text{O}_{12}$	77	866
2.097	Ho^{3+}	$(\text{Ho},\text{Y})_3\text{Al}_5\text{O}_{12}$	77	893
2.0974	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Tm}$	300	746,879,880
2.0975	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	77	278,868
2.0977	Ho^{3+}	$(\text{Y}_3\text{Al}_5\text{O}_{12})$	~ 77	579
2.0978	Ho^{3+}	$\text{Y},\text{Er})_3\text{Al}_5\text{O}_{12}$	77	865
2.0979	Ho^{3+}	$(\text{Y},\text{Er})_3\text{Al}_5\text{O}_{12}$	77	278
2.0982	Ho^{3+}	$(\text{Y},\text{Er})_3\text{Al}_5\text{O}_{12}:\text{Tm}$	77	817
2.0982	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Er},\text{Tm}$	110	817,881
2.0983	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Er},\text{Tm},\text{Yb}$	110	881
2.0985	Ho^{3+}	$\text{Er}_3\text{Sc}_2\text{Al}_3\text{O}_{12}$	77	279
2.0985	Ho^{3+}	$\text{Er}_3\text{Al}_5\text{O}_{12}$	110	848
2.0985–2.0997	Ho^{3+}	ErAlO_3	110	848,882
2.0990	Ho^{3+}	$(\text{Y},\text{Er})_3\text{Al}_5\text{O}_{12}:\text{Tm}$	77	817
2.0995	Ho^{3+}	$\text{Tm}_3\text{Al}_5\text{O}_{12}$	110	848
2.0998	Ho^{3+}	$\text{Yb}_3\text{Al}_5\text{O}_{12}:\text{Er},\text{Tm}$	110	881
2.1	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Tm},\text{Yb}$	110	883,888
2.1	Ho^{3+}	$(\text{Y},\text{Er})_3\text{Sc}_2\text{Ga}_3\text{O}_{12}:\text{Tm}$	77	841,848
2.1	Ho^{3+}	$\text{CaF}_2\text{-ErF}_3\text{-TmF}_3\text{-YbF}_3$	77	836
2.1	Ho^{3+}	$\text{Li}(\text{Y},\text{Er})\text{F}_4$	77–124	884
2.1	Ho^{3+}	$\text{LiYF}_4:\text{Tm}$	77	340
2.1	Ho^{3+}	$(\text{Y},\text{Er},)_3\text{Al}_5\text{O}_{12}$	77	885,886
2.1000	Ho^{3+}	$\text{Yb}_3\text{Al}_5\text{O}_{12}:\text{Tm},\text{Yb}$	110	848
2.1004	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}:\text{Tm}$	300	862
2.1005	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}:\text{Er}$	110	881
2.1005	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}:\text{Er},\text{Tm},\text{Yb}$	110	887
2.1008	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}:\text{Tm}$	110	881
2.101	Ho^{3+}	$\text{Yb}_3\text{Al}_5\text{O}_{12}$	300	858
2.1010	Ho^{3+}	$(\text{Er},\text{Tm},\text{Yb})_3\text{Al}_5\text{O}_{12}$	77	726

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
2.1020	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}:\text{Er,Tm}$	77	794
2.1020	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}$	110	889
2.105	Ho^{3+}	Y_2SiO_5	$\sim 110, 220$	856
2.107	Ho^{3+}	$\text{Y}_3\text{Fe}_5\text{O}_{12}$	77	857
2.1110	Ho^{3+}	$\text{CaF}_2\text{-HoF}_3$	110	791
2.1135	Ho^{3+}	$\text{Ho}_3\text{Ga}_5\text{O}_{12}$	77	713
2.114	Ho^{3+}	$\text{Y}_3\text{Ga}_5\text{O}_{12}:\text{Fe}$	77, >140	860
2.114	Ho^{3+}	$\text{Y}_3\text{Ga}_5\text{O}_{12}$	77	857
2.115	Ho^{3+}	$\text{ZrO}_2\text{-Er}_2\text{O}_3$	77	764
2.1170	Ho^{3+}	$\text{Ho}_3\text{Sc}_2\text{Al}_3\text{O}_{12}$	77	713
2.1185	Ho^{3+}	YAlO_3	110	887
2.1189	Ho^{3+}	YAlO_3	110	190,241
2.119	Ho^{3+}	$(\text{Y,Er})\text{AlO}_3:\text{Tm}$	300	130
2.1193	Ho^{3+}	YAlO_3	110	190
2.12	Ho^{3+}	$(\text{Y,Er})\text{AlO}_3$	233	787
2.12	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Tm}$	215–330	814,890,891
2.1205	Ho^{3+}	ErAlO_3	77	840
2.1205	Ho^{3+}	$(\text{Er,Lu})\text{AlO}_3$	77	840
2.121	Ho^{3+}	Er_2O_3	145	893
2.122	Ho^{3+}	$\text{Ho}_3\text{Al}_5\text{O}_{12}$	90	894
2.1223	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Tm}$	77	881
2.1223	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	278
2.1224	Ho^{3+}	$\text{Ho}_3\text{Al}_5\text{O}_{12}$	~ 90	892
2.1227	Ho^{3+}	$(\text{Y,Er})_3\text{Al}_5\text{O}_{12}:\text{Tm}$	77	817
2.1227	Ho^{3+}	$\text{Ho}_3\text{Al}_5\text{O}_{12}$	77	713
2.123	Ho^{3+}	$(\text{Y,Er})\text{AlO}_3:\text{Tm}$	300	130
2.123	Ho^{3+}	$(\text{Y,Ho})_3\text{Al}_5\text{O}_{12}$	77	278,864
2.1241	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}:\text{Tm}$	300	824
2.1250	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}$	110	887
2.1285	Ho^{3+}	$(\text{Y,Er})_3\text{Al}_5\text{O}_{12}:\text{Tm}$	77	895
2.1285	Ho^{3+}	$\text{Ho}_3\text{Sc}_2\text{Al}_3\text{O}_{12}$	77	713
2.129	Ho^{3+}	$\text{Ho}_3\text{Al}_5\text{O}_{12}$	90	894
2.1294	Ho^{3+}	$\text{Ho}_3\text{Al}_5\text{O}_{12}$	~ 90	892
2.1295	Ho^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	881
2.1297	Ho^{3+}	$\text{Ho}_3\text{Al}_5\text{O}_{12}$	77	713

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
~2.13	Ho^{3+}	$(\text{Y},\text{Er})_3\text{Al}_3\text{O}_{12}:\text{Tm}$	300	896,897
2.1300	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}$	110	887
2.1300	Ho^{3+}	YAlO_3	110	190,887
2.1303	Ho^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}$	300	881
2.134–2.799	Cr^{2+}	ZnSe	300	914
2.1348	Ho^{3+}	LuAlO_3	~90	795
2.165	Co^{2+}	ZnF_2	77	535,801
2.171	Ho^{3+}	$\text{BaY}_2\text{F}_8:\text{Tm}$	295	838
2.20–2.46	Tm^{3+}	LiYF_4	300	912,913
2.234	U^{3+}	CaF_2	77	898
2.274	Tm^{3+}	YAlO_3	300	904
2.2845	Tm^{3+}	BaYb_2F_8	300	711
2.286–2.530	Cr^{2+}	ZnS	300	914
2.30	Tm^{3+}	LiYF_4	300	811
2.303	Tm^{3+}	LiYF_4	110	812
2.318	Tm^{3+}	$\text{YAlO}_3:\text{Cr}$	300	904
2.324	Tm^{3+}	$\text{Y}_3\text{Al}_5\text{O}_{12}$	300	904
2.335	Tm^{3+}	$\text{Gd}_3\text{Sc}_2\text{Ga}_3\text{O}_{12}$	300	710,873
~2.34	Tm^{3+}	$\text{YAlO}_3:\text{Cr}$	90, 300	803
2.3425	Tm^{3+}	$\text{Lu}_3\text{Al}_5\text{O}_{12}$	110	889
2.348	Tm^{3+}	YAlO_3	300	905
2.349	Tm^{3+}	YAlO_3	300	905
~2.35	Cr^{2+}	ZnS	300	915
~2.35	Cr^{2+}	ZnSe	300	915
2.352	Ho^{3+}	LiHoF_4	90	51,124
2.3520	Ho^{3+}	LiYF_4	116	181
2.3524	Ho^{3+}	LiYF_4	116	750
2.353	Tm^{3+}	$\text{YAlO}_3:\text{Cr}$	300	904
2.354	Tm^{3+}	$\text{YAlO}_3:\text{Cr}$	300	904
2.355	Tm^{3+}	$\text{YAlO}_3:\text{Cr}$	300	904
2.358	Dy^{2+}	CaF_2	4.2, 77	877,906-911
2.362	Ho^{3+}	BaY_2F_8	77	838
2.363	Ho^{3+}	BaY_2F_8	77	838
2.3659	Dy^{2+}	SrF_2	20	903
2.375	Ho^{3+}	BaY_2F_8	77	838
2.407	U^{3+}	SrF_2	20–90	902
2.439	U^{3+}	CaF_2	77	899

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
2.511	U ³⁺	CaF ₂	77	899,900
2.515	Cr ²⁺	Cd _{0.85} Mn _{0.15} Te	300	1031
2.556	U ³⁺	BaF ₂	20	901
2.571	U ³⁺	CaF ₂	77	900
2.6	U ³⁺	CaF ₂	4.2	932
2.613	U ³⁺	CaF ₂	77–90	933
2.62–2.94	Er ³⁺	Y ₃ Al ₅ O ₁₂ :Cr,Tm	300	934
2.66	Er ³⁺	LiYF ₄	300	935
2.6887	Er ³⁺	K(Y,Er)(WO ₄) ₂	300–150	855
2.69	Er ³⁺	CaF ₂ -ErF ₃ -TmF ₃	298	936
2.6930	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	77	237
2.6970	Er ³⁺	Er ₃ Al ₅ O ₁₂	110	51,882
2.6975	Er ³⁺	Y ₃ Al ₅ O ₁₂ :Tm,Yb	300	938
[2.6975–2.6979]	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	110	918
2.6987	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	110	918
2.699	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	300	51,919,920
2.6990	Er ³⁺	(Er,Lu) ₃ Al ₅ O ₁₂	300	239
2.6990	Er ³⁺	Lu ₃ Al ₅ O ₁₂ :Ho,Tm	300	239
2.7	Er ³⁺	SrLaGa ₃ O ₇ :Pr	300	733
2.7	Er ³⁺	Y ₃ Al ₅ O ₁₂ :Cr	300	776
2.7	Er ³⁺	Y ₃ Sc ₂ Al ₃ O ₁₂	300	776
2.7034	Er ³⁺	Gd ₃ Ga ₅ O ₁₂	110	877
2.707	Er ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂	300	776
2.71	Er ³⁺	Ca ₃ (NbLiGa) ₅ O ₁₂	300	929
[2.71–2.86]	Er ³⁺	(Y,Er)AlO ₃	300	916
2.7118	Er ³⁺	(Y,Er)AlO ₃	300	922
2.7126	Er ³⁺	LuAlO ₃	110	792
2.7140–43	Er ³⁺	(Er,Lu) ₃ Al ₅ O ₁₂	100	918
2.7170	Er ³⁺	LiYF ₄	110	788
2.7175	Er ³⁺	Ca(NbO ₃) ₂	110	57
2.7188	Er ³⁺	Gd ₃ Ga ₅ O ₁₂	110	877
2.7220	Er ³⁺	KLa(MoO ₄) ₂	110	501
2.7222	Er ³⁺	KGd(WO ₄) ₂	300	796
2.7285	Er ³⁺	SrF ₂ -ErF ₃	300	921
2.7290	Er ³⁺	CaF ₂ -ErF ₃	300	791

Table 2.1.4 continued
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
2.7295	Er ³⁺	CaF ₂ -ErF ₃	300	791
[2.73–2.92]	Er ³⁺	(Y,Er)AlO ₃	300	917
2.73	Er ³⁺	YAlO ₃	290–330	968
2.7305–2.7307	Er ³⁺	YAlO ₃	300	788,789,922
2.7307(a)	Er ³⁺	CaF ₂ -ErF ₃	300	997
2.7307	Er ³⁺	CaF ₂	300	998
2.7309	Er ³⁺	YAlO ₃	300	129
2.7310	Er ³⁺	(Y,Er)AlO ₃	110	788,789,792,930
2.7398	Er ³⁺	(Y,Er)AlO ₃	110	788,789,792,930
2.7417	Er ³⁺	BaEr ₂ F ₈	110	115,927
2.7450	Er ³⁺	SrF ₂ -ErF ₃	300	921
2.7460	Er ³⁺	CaF ₂ -ErF ₃	300	791
2.747	Er ³⁺	LiYF ₄	300	776
2.7490	Er ³⁺	CaF ₂ -ErF ₃	300	791
2.75	Er ³⁺	CaF ₂ -ErF ₃	300	923-926
2.7575	Er ³⁺	KLa(MoO ₄) ₂	300	501
2.7595	Er ³⁺	BaEr ₂ F ₈	110	115,927
2.7608	Er ³⁺	(Y,Er)AlO ₃	110	788,789,792,930
2.766	Er ³⁺	Y ₃ Al ₅ O ₁₂	300	928
2.7645	Er ³⁺	(Y,Er)AlO ₃	300	922
2.7698	Er ³⁺	(Y,Er)AlO ₃	110	788,789
2.77	Er ³⁺	LiYF ₄	300	943
2.79	Er ³⁺	(Y,Er)AlO ₃	290–330	968
2.791	Er ³⁺	Y ₃ Sc ₂ Ga ₃ O ₁₂	300	942,956,962
2.7930	Er ³⁺	SrF ₂ -ErF ₃	300	921
2.794	Er ³⁺	Gd ₃ Ga ₅ O ₁₂ :Ce	300	1036
2.795	Er ³⁺	Y ₃ Al ₅ O ₁₂	300	928
2.7953	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	300	964
2.7953–2.7958	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	300	918
2.7955	Er ³⁺	CaF ₂ -ErF ₃	300	971
2.7955	Er ³⁺	(Y,Er)AlO ₃	300	788,930
2.7969	Er ³⁺	(Y,Er)AlO ₃	110	788,789
2.7973	Er ³⁺	Lu ₃ Al ₅ O ₁₂	300	918
2.7980	Er ³⁺	BaEr ₂ F ₈	110	115,927
2.7985	Er ³⁺	CaF ₂ -ErF ₃	300	944,971
2.799	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	300	51
2.7990	Er ³⁺	KGd(WO ₄) ₂	300	796

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
2.7998	Er ³⁺	Lu ₃ Al ₅ O ₁₂	110	918
2.8	Er ³⁺	LiYF ₄	300	961
2.80	Er ³⁺	CaF ₂ -ErF ₃	300	923-926
2.80	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	300	969-972
2.80	Er ³⁺	SrF ₂ -ErF ₃	300	926
2.80	Er ³⁺	Er _{2.7} Gd _{0.3} Al ₅ O ₁₂	110	367
2.8070	Er ³⁺	KY(WO ₄) ₂	300	236,328
2.8070	Er ³⁺	KEr(WO ₄) ₂	300	339
2.8085	Er ³⁺	LiYF ₄	110	788
2.8092	Er ³⁺	KLu(WO ₄) ₂	300	938
2.81	Er ³⁺	LiYF ₄	300	926,935
2.810	Er ³⁺	LiYF ₄	300	755,926
2.8128	Er ³⁺	Gd ₃ Ga ₅ O ₁₂	300	938
2.8218	Er ³⁺	Gd ₃ Ga ₅ O ₁₂	300	942
2.822	Er ³⁺	Gd ₃ Ga ₅ O ₁₂ :Ce	300	1036
2.8230	Er ³⁺	(Y,Er)AlO ₃	300	922
2.827	U ³⁺	LiYF ₄	300	945
2.8297-2.8302	Er ³⁺	Lu ₃ Al ₅ O ₁₂	300	918
2.8298	Er ³⁺	(Er,Lu) ₃ Al ₅ O ₁₂ :Yb	300	51,941
2.8298	Er ³⁺	(Er,Lu) ₃ Al ₅ O ₁₂	300	918
2.83	Ho ³⁺	LiYbF ₄	300	850
2.830	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	300	947,986
2.8302	Er ³⁺	Y ₃ Al ₅ O ₁₂	300	940
2.8302	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	300	964
2.8302	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	300	964
2.8302	Er ³⁺	Y ₃ Al ₅ O ₁₂ :Tm	300	938
2.84	Er ³⁺	LiYF ₄	300	935
2.8400	Er ³⁺	(Y,Er)AlO ₃	300	922
2.8415	Ho ³⁺	KLa(MoO ₄) ₁₂	110	501
2.8484	Ho ³⁺	GdVO ₄ :Tm	300	578
2.85	Er ³⁺	LiYF ₄	300	935
2.850	Ho ³⁺	LiYF ₄	300	181
2.8500	Er ³⁺	LiErF ₄	110	233
2.8510	Ho ³⁺	LaNbO ₄ :Er	90	958
2.8549	Er ³⁺	Gd ₃ Ga ₅ O ₁₂	110	877

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
2.8552–2.8590	Er ³⁺	Lu ₃ Al ₅ O ₁₂	110	918
2.8575	Ho ³⁺	BaYb ₂ F ₈ :Yb	300	203,848
2.8578	Ho ³⁺	YAlO ₃	300	952
2.8595	Er ³⁺	Er ₃ Al ₅ O ₁₂	110	882
2.86	Er ³⁺	Er ₃ Al ₅ O ₁₂	110	465
2.86	Er ³⁺	Er _{2.7} Gd _{0.3} Al ₅ O ₁₂	110	368
2.8637	Ho ³⁺	YScO ₃ :Gd	77	783
2.8665	Er ³⁺	(Y,Er)AlO ₃	300	922
2.870	Er ³⁺	LiYF ₄	110, 300	939
2.8700	Er ³⁺	Lu ₃ Al ₅ O ₁₂	110	918
2.8748–2.8752	Er ³⁺	Lu ₃ Al ₅ O ₁₂	110	918
2.8750	Er ³⁺	Er ₃ Al ₅ O ₁₂	110	882
2.8756	Er ³⁺	(Y,Er)AlO ₃	300	922
2.8758	Er ³⁺	(Y,Er)AlO ₃	300	922
2.8760	Er ³⁺	Lu ₃ Al ₅ O ₁₂	110	918
2.8868	Er ³⁺	Er ₃ Al ₅ O ₁₂	110	918
2.8967–2.8979	Er ³⁺	Lu ₃ Al ₅ O ₁₂	110	918
2.8970	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	77	237
2.9	Ho ³⁺	Gd ₃ Ga ₅ O ₁₂	300	918
2.9	Ho ³⁺	BaYb ₂ F ₈ :Yb	300	51,161,703,964
2.9054	Ho ³⁺	BaYb ₂ F ₈ :Yb	300	966
2.9073	Ho ³⁺	BaYb ₂ F ₈	~300	966
2.9073	Ho ³⁺	BaYb ₂ F ₈	293	989
2.9155	Ho ³⁺	YAlO ₃	300	783
2.9180	Ho ³⁺	YAlO ₃	300	129,792,930
2.9185	Ho ³⁺	YAlO ₃	110–300	190
2.9200	Ho ³⁺	YAlO ₃	110	241,792,930
2.9230	Ho ³⁺	ErAlO ₃	110	792
2.9342	Ho ³⁺	KGd(WO ₄) ₂	300	796
2.936	Er ³⁺	Y ₃ Al ₅ O ₁₂		731
2.9362–2.9366	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	300	918,964
2.9364	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	300	225,237,926, 973-975
2.9365	Er ³⁺	Y ₃ Al ₅ O ₁₂ :Tm,Yb	300	938,942
2.9365	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	300	964
2.9365	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	300	964
2.9366	Er ³⁺	Er ₃ Al ₅ O ₁₂	300	918

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
2.9367	Er ³⁺	Er ₃ Al ₅ O ₁₂	300	882
2.937	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	300	926
2.937	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	300	926
2.939	Er ³⁺	Y ₃ Al ₅ O ₁₂	300	928
2.9395	Er ³⁺	Lu ₃ Al ₅ O ₁₂ :Yb	300	239,941
2.9395	Er ³⁺	Lu ₃ Al ₅ O ₁₂	300	239
2.9395	Er ³⁺	Er ₃ Al ₅ O ₁₂	110	882
2.9395	Ho ³⁺	KY(WO ₄) ₂ :Er,Tm	300	959
2.9395	Er ³⁺	Er ₃ Al ₅ O ₁₂	110	882
2.9395–2.9397	Er ³⁺	Lu ₃ Al ₅ O ₁₂	110	918
2.94	Er ³⁺	Er _{3-x} Gd _{0,x} Al ₅ O ₁₂	300	367
2.94	Er ³⁺	Y ₃ Al ₅ O ₁₂ :Cr	300	957,992
2.94	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	300	918
2.94	Er ³⁺	Er ₃ Al ₅ O ₁₂	110	882
2.94	Er ³⁺	Y ₃ Al ₅ O ₁₂ :Nd	300	672
2.940	Ho ³⁺	Y ₃ Al ₅ O ₁₂ :Ho	300	673
2.9401	Er ³⁺	Lu ₃ Al ₅ O ₁₂	110	918
2.9403	Ho ³⁺	Y ₃ Al ₅ O ₁₂	300	129
2.9403	Er ³⁺	(Lu,Er) ₃ Al ₅ O ₁₂	300	918
2.9403	Er ³⁺	Y ₃ Al ₅ O ₁₂	300	129
2.9405	Er ³⁺	Lu ₃ Al ₅ O ₁₂ :Yb	300	941
2.9408	Er ³⁺	Lu ₃ Al ₅ O ₁₂	300	239
2.943	Er ³⁺	(Y,Er) ₃ Al ₅ O ₁₂	110	359
2.9445	Ho ³⁺	KLu(WO ₄) ₂	300	965
2.9460	Ho ³⁺	Lu ₃ Al ₅ O ₁₂ :Cr,Yb	300	129,941
2.952	Ho ³⁺	LiYF ₄	300	750
2.952	Ho ³⁺	LiYF ₄	116–300	189
2.955	Ho ³⁺	LiYF ₄	300	967
2.9619	Ho ³⁺	Gd ₃ Ga ₅ O ₁₂	110	887
2.97	Dy ³⁺	LaF ₃	300	759
2.9700	Ho ³⁺	KLa(MoO ₄) ₂	300	501
3.011	Ho ³⁺	Y ₃ Al ₅ O ₁₂	300	673
3.0132	Ho ³⁺	YAlO ₃	300	129,930,948
3.0157	Ho ³⁺	YAlO ₃	110	792,910
3.0165	Ho ³⁺	YAlO ₃	110–300	190

Table 2.1.4 *continued*
Paramagnetic Ion Lasers Arranged in Order of Wavelength

Wavelength (μm)	Ion	Host: sensitizer ion(s)	Temp. (K)	References
3.0177	Ho^{3+}	YAlO_3	110	792
3.02	Dy^{3+}	BaY_2F_8	300	965
3.022	Dy^{3+}	$\text{Ba}(\text{Y},\text{Er})_2\text{F}_8$	77	960
3.369	Ho^{3+}	LiYF_4	300	967
3.377	Ho^{3+}	BaY_2F_8	20	838
3.40	Dy^{3+}	BaY_2F_8	300	1029
3.41	Er^{3+}	LiYF_4	300	951
3.53	Fe^{2+}	n-InP	2	748
3.6050	Pr^{3+}	$\text{BaYb}_2\text{F}_8:\text{Yb}$	110	241,623
3.893	Ho^{3+}	LiYF_4	300	967
3.914	Ho^{3+}	LiYF_4	300	915
4.34	Dy^{3+}	LiYF_4	300	990
4.75	Er^{3+}	YAlO_3	110	958-960,965
5.15	Nd^{3+}	$\text{BaF}_2\text{-LaF}_3$	300	161,959,991
5.242	Pr^{3+}	LaCl_3	130	760
7.141	Pr^{3+}	LaCl_3	~ 300	955
7.152	Pr^{3+}	LaCl_3	~ 30	955
7.24	Pr^{3+}	LaCl_3	148	950
7.244	Pr^{3+}	LaCl_3	130	955

(a) Stimulated emission and or wavelength requires more accurate definition.

(b) Self-frequency-doubled emission.

(c) Center wavelength of lasing tuning range.

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Section 2.2

GLASS LASERS

Introduction to the Tables

Glass lasers have used lanthanide ions almost exclusively as the active ion. The lasing transitions for these ions and approximate wavelengths are given in [Table 2.2.1](#). Although the exact wavelength varies slightly with host glass composition and temperature, this table can generally be used to identify the transition involved in laser action.

A few ion-glass systems in which only gain has been reported are listed in [Table 2.2.2](#).

Glass lasers and amplifiers based on lanthanide ions are arranged in order of increasing wavelength in [Table 2.2.3](#). Lasers that have been tuned over a range of wavelengths are listed by the lowest wavelength reported; the tuning range given is that for the configuration and conditions used and may not represent the extremes possible. The lasing ion is listed in the second column. The host glass type is specified by the glass network former (silicate, phosphate, etc.) and, if known, the principal glass network modifier cation(s). If codopants or sensitizing ions are added, they are listed following the colon. The form of the glass—bulk (rod, disk), fiber, or planar waveguide—is noted in the fourth column.

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Table 2.2.1
Glass Laser Transitions

Wavelength* (μm)	Ion	Transition
0.38	Nd ³⁺	$4D_{3/2} \rightarrow 4I_{11/2}$
0.41	Nd ³⁺	$2P_{3/2} \rightarrow 4I_{11/2}$
0.46	Tm ³⁺	$1D_2 \rightarrow 3F_4$
0.48	Tm ³⁺	$1G_4 \rightarrow 3H_6$
0.49	Pr ³⁺	$3P_0 \rightarrow 3H_4$
0.52	Pr ³⁺	$3P_1 \rightarrow 3H_5$
0.54	Tb ³⁺	$5D_4 \rightarrow 7F_5$
0.55	Er ³⁺	$4S_{3/2} \rightarrow 4I_{15/2}$
0.55	Ho ³⁺	$5S_2 \rightarrow 5I_8$
0.61	Pr ³⁺	$3P_0 \rightarrow 3H_6$
0.64	Pr ³⁺	$3P_0 \rightarrow 3F_2$
0.65	Sm ³⁺	$4G_{5/2} \rightarrow 6H_{9/2}$
0.70	Pr ³⁺	$3P_1 \rightarrow 3F_4$
0.72	Pr ³⁺	$3P_1 \rightarrow 3F_4$
0.75	Ho ³⁺	$5S_2 \rightarrow 5I_7$
0.82	Tm ³⁺	$3H_4 \rightarrow 3H_6$
0.85	Er ³⁺	$4S_{3/2} \rightarrow 4I_{13/2}$
0.88	Pr ³⁺	$3P_1 \rightarrow 1G_4$
0.89	Pr ³⁺	$3P_0 \rightarrow 1G_4$
0.93	Nd ³⁺	$4F_{3/2} \rightarrow 4I_{9/2}$
0.93	Pm ³⁺	$5F_1 \rightarrow 5I_5$
0.99	Er ³⁺	$4I_{11/2} \rightarrow 4I_{15/2}$
1.03	Yb ³⁺	$2F_{5/2} \rightarrow 2F_{7/2}$
1.06	Nd ³⁺	$4F_{3/2} \rightarrow 4I_{11/2}$
1.08	Pr ³⁺	$1D_2 \rightarrow 3F_{3,4}$
1.10	Pm ³⁺	$5F_1 \rightarrow 5I_6$
1.2	Ho ³⁺	$5I_6 \rightarrow 5I_8$
1.31	Pr ³⁺	$1G_4 \rightarrow 3H_5$
1.34	Nd ³⁺	$4F_{3/2} \rightarrow 4I_{13/2}$
1.38	Ho ³⁺	$5S_2, 5F_4 \rightarrow 5I_5$

Table 2.2.1—continued
Glass Laser Transitions

Wavelength* (μm)	Ion	Transition
1.48	Tm ³⁺	$^3\text{H}_4 \rightarrow ^3\text{F}_4$
1.51	Tm ³⁺	$^1\text{D}_2 \rightarrow ^1\text{G}_4$
1.55	Er ³⁺	$^4\text{I}_{13/2} \rightarrow ^4\text{I}_{15/2}$
1.66	Er ³⁺	$^2\text{H}_{11/2} \rightarrow ^4\text{I}_{9/2}$
1.72	Er ³⁺	$^4\text{S}_{3/2} \rightarrow ^4\text{I}_{9/2}$
1.88	Tm ³⁺	$^3\text{F}_4 \rightarrow ^3\text{H}_6$
2.05	Ho ³⁺	$^5\text{I}_7 \rightarrow ^5\text{I}_8$
2.3	Tm ³⁺	$^3\text{H}_4 \rightarrow ^3\text{H}_5$
2.75	Er ³⁺	$^4\text{I}_{11/2} \rightarrow ^4\text{I}_{13/2}$
2.9	Ho ³⁺	$^5\text{I}_6 \rightarrow ^5\text{I}_7$
3.5	Er ³⁺	$^4\text{F}_{9/2} \rightarrow ^4\text{I}_{9/2}$
3.9	Ho ³⁺	$^5\text{I}_5 \rightarrow ^5\text{I}_6$

*Wavelengths of transitions are only approximate; exact wavelengths are dependent on the host and temperature and the specific Stark levels involved.

Table 2.2.2
Ions in Glasses Exhibiting Gain

Wavelength (μm)	Ion	Host glass (sensitizer)	Form	Reference
0.543	Ho^{3+}	fluorozircoaluminate (Yb)	fiber	1
0.546	Er^{3+}	fluorozirconate	fiber	2
0.560–0.585	Cu^{+}	aluminoborosilicate	bulk	3
0.625	CdSSe	silicate	bulk	4
0.633	Cu^{+}	fluorohafnate	bulk	5
1.083	Nd^{3+}	chalcogenide	fiber	6
1.536	Er^{3+}	silica	fiber	7
2.05	Ho^{3+}	alumino-zirco- fluoride(Tm^{3+})	bulk	8

References—Table 2.2.2

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Table 2.2.3
Glass Lasers Arranged in Order of Increasing Wavelength

Wavelength ^(a) (μm)	Ion	Host glass ^(b)	Form	Reference
0.381	Nd ³⁺	fluorozirconate	fiber	1
0.412	Nd ³⁺	fluorozirconate	fiber	2
0.455	Tm ³⁺	fluorozirconate	fiber	3,4
0.480	Tm ³⁺	fluorozirconate	fiber	3,5
0.482	Tm ³⁺	fluorozirconate	fiber	15
0.491	Pr ³⁺	fluorozirconate	fiber	6,7
0.491–0.493	Pr ³⁺	fluorozirconate (Yb)	fiber	8
0.492	Pr ³⁺	fluorozirconate	fiber	9
0.517–0.540	Pr ³⁺	fluorozirconate (Yb)	fiber	8
0.520	Pr ³⁺	fluorozirconate	fiber	6,7
0.521	Pr ³⁺	fluorozirconate	fiber	10
~0.539–550	Ho ³⁺	fluorozirconate	fiber	17
0.54 ^(c)	Tb ³⁺	borate	bulk	11
0.540–0.545 ^(d)	Er ³⁺	fluorozirconate	fiber	12
0.540–0.553	Ho ³⁺	fluorozirconate	fiber	13
0.546	Er ³⁺	fluorozirconate	fiber	12,14
0.548	Er ³⁺	fluorozirconate	fiber	16
0.599–0.611	Pr ³⁺	fluorozirconate	fiber	7
0.601–0.618	Pr ³⁺	fluorozirconate	fiber	18
0.602	Pr ³⁺	fluorozirconate (Yb)	fiber	19
0.605	Pr ³⁺	fluorozirconate	fiber	6
0.605–0.622	Pr ³⁺	fluorozirconate (Yb)	fiber	8
0.631–0.641	Pr ³⁺	fluorozirconate	fiber	7,18
0.6328	Pr ³⁺	fluorozirconate	fiber	20
0.635	Pr ³⁺	fluorozirconate	fiber	6,7,10
0.635	Pr ³⁺	fluorozirconate (Yb)	fiber	19,23
0.635–0.637	Pr ³⁺	fluorozirconate (Yb)	fiber	8
0.651	Sm ³⁺	silica	fiber	24
0.690–0.703	Pr ³⁺	fluorizirconate	fiber	18
0.707–0.725	Pr ³⁺	fluorozirconate	fiber	18

Table 2.2.3—continued
Glass Lasers Arranged in Order of Increasing Wavelength

Wavelength^(a) (μm)	Ion	Host glass^(b)	Form	Reference
0.715	Pr ³⁺	fluorozirconate	fiber	6,7
0.7495–0.7545	Ho ³⁺	fluorozirconate	fiber	13
0.800–0.830	Tm ³⁺	fluorozirconate	fiber	25,26
0.803–0.816	Tm ³⁺	fluorozirconate	fiber	27
0.815–0.825	Tm ³⁺	fluorozirconate	fiber	28
0.85	Er ³⁺	fluorozirconate	fiber	29,30
0.880–0.886	Pr ³⁺	fluorozirconate	fiber	18
0.89	Pr ³⁺	silica (Ge)	fiber	31
0.899–0.951	Nd ³⁺	silica	fiber	32,33
0.902–0.916	Pr ³⁺	fluorozirconate	fiber	18
0.905	Nd ³⁺	phosphate	planar	21
0.918	Nd ³⁺	Na–Ca silicate	bulk	34
0.92	Nd ³⁺	silicate	bulk	35
0.933	Pm ³⁺	Pb–In phosphate	bulk	36
0.938	Nd ³⁺	silica	fiber	37,38
0.974	Yb ³⁺	silica	fiber	39
0.980	Yb ³⁺	silica (Al,P)	fiber	40
0.981–1.004	Er ³⁺	fluorozirconate	fiber	41
1.00	Er ³⁺	fluorozirconate	fiber	42
1.000–1.050	Yb ³⁺	fluorozirconate	fiber	43
1.000–1.085	Pr ³⁺	silica	fiber	44
1.010–1.162	Yb ³⁺	silica	fiber	39
1.015	Yb ³⁺	Li–Mg–Al silicate	bulk	45,46
1.015–1.140	Yb ³⁺	silica	fiber	47
1.018	Yb ³⁺	Ca–Li borate (Nd)	bulk	48
1.020	Yb ³⁺	fluorozirconate	fiber	43
1.028–1.064	Yb ³⁺	silica	fiber	47
1.047	Nd ³⁺	fluoroberyllate	bulk	49
1.05	Nd ³⁺	phosphate	fiber	50
1.05	Nd ³⁺	phosphate (LG–760)	planar	51

Table 2.2.3—continued
Glass Lasers Arranged in Order of Increasing Wavelength

Wavelength^(a) (μm)	Ion	Host glass^(b)	Form	Reference
1.050	Nd ³⁺	fluorozirconate	fiber	52
1.050–1.075	Nd ³⁺	silicate (P)	fiber	53
1.051	Nd ³⁺	fluorophosphate	bulk	54
1.051	Nd ³⁺	fluorozirconate	microsphere	197
1.0515	Nd ³⁺	silica (P)	planar	55
1.0525	Nd ³⁺	silica (P)	planar	56
1.053	Nd ³⁺	silica	planar	57
1.0535	Nd ³⁺	Na–K–Cd phosphate	bulk	58
1.054	Nd ³⁺	phosphate (LHG–5)	planar	59
1.054	Nd ³⁺	phosphate (LHG–8)	bulk	60
1.054	Nd ³⁺	Zn–Li phosphate	bulk	61,62
1.0546	Nd ³⁺	phosphate (APG-1)	bulk	22
1.055	Nd ³⁺	Li–Nd–La phosphate	bulk	63
1.055	Nd ³⁺	silica (P)	fiber	64
1.057	Nd ³⁺	silicate (LG–660)	planar	65
1.057	Nd ³⁺	phosphate	planar	21
1.058	Nd ³⁺	borosilicate (BK–7)	planar	66
1.06	Nd ³⁺	Ba silicate	planar	67
1.06	Nd ³⁺	borate	bulk	68
1.06	Nd ³⁺	borosilicate	planar	69
1.06	Nd ³⁺	glass ceramic	bulk	70,71
1.06	Nd ³⁺	lead silicate (F7)	fiber	72
1.06	Nd ³⁺	Li germanate	bulk	73
1.06	Nd ³⁺	Li–La phosphate (Cr)	bulk	74
1.06	Nd ³⁺	silicate	bulk	75
1.06	Nd ³⁺	silicate	fiber	76
~1.06	Nd ³⁺	silicate (GLS2, GLS3)	planar	77
1.06	Yb ³⁺	K–Ba silicate	bulk	78
1.060	Nd ³⁺	silica (Al)	fiber	79
1.060	Nd ³⁺	silica (Al)	planar	80
1.0605	Nd ³⁺	Li tellurite	bulk	58,81

Table 2.2.3—continued
Glass Lasers Arranged in Order of Increasing Wavelength

Wavelength^(a) (μm)	Ion	Host glass^(b)	Form	Reference
1.061	Nd ³⁺	K–Ba silicate	bulk	82
1.061	Nd ³⁺	tellurite	fiber	83
1.062	Nd ³⁺	silicate (buffer)	bulk	84
1.0635	Nd ³⁺	silica (Al)	bulk	85
1.064	Nd ³⁺	Ba silicate	planar	86
1.066	Nd ³⁺	tellurite	bulk	87
1.069–1.144	Nd ³⁺	silica	fiber	33,34,88
1.08	Nd ³⁺	chalcogenide (Ga:La:S)	bulk	89
1.08	Pr ³⁺	silica	bulk	31
1.088	Nd ³⁺	silica (Al)	fiber	90,91
1.088	Nd ³⁺	silica (Ge)	fiber	92
1.098	Pm ³⁺	Pb–In phosphate	bulk	36
1.12	Yb ³⁺	silica (Ge)	fiber	93
1.128	Yb ³⁺	germanosilicate	fiber	195
1.134	Yb ³⁺	germanosilicate	fiber	195
1.19	Ho ³⁺	fluorozirconate	fiber	127
1.24–1.34	Pr ³⁺	fluorozirconate	fiber	94
1.28–1.34	Pr ³⁺	fluorozirconate	fiber	95
1.290–1.320	Pr ³⁺	fluorozirconate	fiber	96
1.294	Pr ³⁺	fluorozirconate	fiber	97
1.3	Pr ³⁺	fluorozirconate (Yb)	fiber	98
1.31	Pr ³⁺	fluorozirconate	fiber	99
1.310–1.370	Nd ³⁺	fluorozirconate	fiber	100
1.31–1.36	Nd ³⁺	fluorozirconate	fiber	101
1.32	Nd ³⁺	Li–Nd–La phosphate	bulk	63
1.323	Nd ³⁺	fluorophosphate	fiber	102
1.325	Nd ³⁺	phosphate (LHG–5)	planar	103
1.328	Nd ³⁺	fluorophosphate	fiber	102
1.334	Nd ³⁺	fluorozirconate	microsphere	197
1.338	Nd ³⁺	fluorozirconate	fiber	104
1.340	Nd ³⁺	fluorozirconate	fiber	105

Table 2.2.3—continued
Glass Lasers Arranged in Order of Increasing Wavelength

Wavelength^(a) (μm)	Ion	Host glass^(b)	Form	Reference
1.345	Nd ³⁺	fluorozirconate	fiber	106
1.350	Nd ³⁺	fluorozirconate	fiber	107
1.355	Nd ³⁺	fluorophosphate	fiber	102
1.355	Nd ³⁺	phosphate (LHG-5)	planar	103
1.356	Nd ³⁺	phosphate	planar	21
1.36	Nd ³⁺	silica (P)	fiber	4
1.363	Nd ³⁺	phosphate	fiber	108
1.366	Nd ³⁺	phosphate (LHG-8)	fiber	109
1.37	Nd ³⁺	La-Ba-Th borate	bulk	110
1.38	Ho ³⁺	fluorozirconate	fiber	111
1.46–1.51	Tm ³⁺	fluorozirconate	fiber	28
~1.47	Tm ³⁺	fluorozirconate	fiber	112
1.47	Tm ³⁺	fluorozirconate (Tb ³⁺)	bulk	113
1.475	Tm ³⁺	fluorozirconate	fiber	114
1.475(e)	Tm ³⁺	fluorozirconate	fiber	115
1.48	Tm ³⁺	fluorozirconate	fiber	28
1.481	Tm ³⁺	fluorozirconate (Tb)	fiber	116
1.50–1.70	Er ³⁺	silica	fiber	117
1.51	Tm ³⁺	fluorozirconate	fiber	3
1.52–1.57	Er ³⁺	silica (Ge,Al,P)	fiber	118
1.527–1560	Er ³⁺	aluminosilicate	fiber	119
1.529–1.554	Er ³⁺	silica	fiber	32
1.530–1.565	Er ³⁺	silica (Ge,Ca,Al)	fiber	120
1.530–1.570	Er ³⁺	fluorozirconate	fiber	121
1.531–1.540	Er ³⁺	phosphate (Yb)	bulk	122
1.5321–1.5348	Er ³⁺	phosphate (Yb)	bulk	123
1.533	Er ³⁺	phosphate (Yb)	bulk	124
1.535	Er ³⁺	phosphate	fiber	125
1.535	Er ³⁺	phosphate (Yb)	microchi p	126
1.535	Er ³⁺	silica	fiber	127

Table 2.2.3—continued
Glass Lasers Arranged in Order of Increasing Wavelength

Wavelength^(a) (μm)	Ion	Host glass^(b)	Form	Reference
1.5354	Er ³⁺	silica	fiber	128
1.536	Er ³⁺	silica (Ge)	fiber	129
1.536–1.596	Er ³⁺	fluorophosphate (Cr,Yb)	bulk	130
1.54	Er ³⁺	Al–Zn phosphate (Yb)	bulk	131
1.54	Er ³⁺	fluorophosphate (Yb)	bulk	132
1.54	Er ³⁺	Ba phosphate (Cr,Yb)	bulk	133
1.54	Er ³⁺	phosphate	bulk	134
1.54	Er ³⁺	phosphate	fiber	135
1.54	Er ³⁺	phosphate (Cr,Yb)	bulk	136
1.54	Er ³⁺	phosphate (Yb)	bulk	137-139
1.54	Er ³⁺	silica (Yb)	fiber	140
1.540	Er ³⁺	borosilicate (BK 7)	planar	141
1.540	Er ³⁺	phosphate (Yb)	bulk	142
1.543	Er ³⁺	fluorozirconate	fiber	143
1.543	Er ³⁺	Na–K Ba silicate (Yb)	bulk	144
1.545	Er ³⁺	phosphate (Yb)	bulk	124
1.546	Er ³⁺	silica (P)	planar	145
1.549–1.563	Er ³⁺	phosphate (Yb)	bulk	122
1.55	Er ³⁺	Na–K–Ba silicate	bulk	146
1.55	Er ³⁺	silica	fiber	147
1.55	Er ³⁺	silica	fiber	148
1.55	Er ³⁺	silica (Ge)	fiber	149
1.552	Er ³⁺	silica (Ge)	fiber	150
1.553	Er ³⁺	silica	fiber	127
1.553–1.603	Er ³⁺	silica	fiber	151
1.56	Er ³⁺	silica (Al,P,Yb)	fiber	152,153
1.56	Er ³⁺	silica (Yb)	fiber	154
1.560	Er ³⁺	silica (Al,P)	fiber	155
1.566	Er ³⁺	silica (Ge)	fiber	156
1.57–1.61	Er ³⁺	silica (Al, Ge)	fiber	157

Table 2.2.3—continued
Glass Lasers Arranged in Order of Increasing Wavelength

Wavelength^(a) (μm)	Ion	Host glass^(b)	Form	Reference
1.598	Er ³⁺	silica (P)	planar	158
1.6	Er ³⁺	fluoroaluminate	bulk	159
1.604	Er ³⁺	silica (P)	planar	158
1.65–1.86	Tm ³⁺	silica (Ge)	fiber	160
1.653–1.691	Tm ³⁺	silica	fiber	161
1.660	Er ³⁺	fluorozirconate	fiber	162
1.70–2.00	Tm ³⁺	silica (Al)	fiber	160
1.720	Er ³⁺	fluorozirconate	fiber	162
1.724 ^(f)	Er ³⁺	fluorozirconate	fiber	163
1.780–2.056	Tm ³⁺	silica	fiber	164
1.818–1.858	Tm ³⁺	fluorozirconate	fiber	165
1.84–1.94	Tm ³⁺	fluorozirconate	fiber	28
1.85	Tm ³⁺	Li–Mg–Al silicate	bulk	166
1.870–1.930	Tm ³⁺	fluorozirconate	fiber	165
1.88	Tm ³⁺	fluorozirconate	bulk	167
1.88	Tm ³⁺	lead germanate	fiber	168
1.88–1.96	Tm ³⁺	silica	fiber	169
~1.9	Tm ³⁺	fluorozirconate	fiber	112
1.9	Tm ³⁺	silica	fiber	170
1.905	Tm ³⁺	lead germanate	fiber	168
1.925	Tm ³⁺	fluorozirconate	fiber	165
1.937	Tm ³⁺	silica	fiber	171
1.94–1.96	Tm ³⁺	silica (Ge)	fiber	172
1.960–2.032	Ho ³⁺	silica (Tm)	fiber	173
1.972	Tm ³⁺	fluorozirconate	fiber	174
2.007	Tm ³⁺	silica	fiber	171
2.015	Tm ³⁺	Li–Mg–Al silicate	bulk	166
2.04	Ho ³⁺	fluorozirconate (Tm)	fiber	175
2.04	Ho ³⁺	silica (Ge)	fiber	176
2.049	Tm ³⁺	silica	fiber	171

Table 2.2.3—continued
Glass Lasers Arranged in Order of Increasing Wavelength

Wavelength^(a) (μm)	Ion	Host glass^(b)	Form	Reference
2.054	Ho ³⁺	fluorozirconate (Tm)	fiber	177
2.06–2.10	Ho ³⁺	silicate (Er,Yb)	fiber	178
2.076	Ho ³⁺	fluorozirconate (Tm)	fiber	177
2.08	Ho ³⁺	fluorozirconate	fiber	111
2.08	Ho ³⁺	Li–Mg–Al silicate	bulk	179
2.09	Ho ³⁺	germanate	bulk	196
2.102	Tm ³⁺	silica	fiber	171
2.25	Tm ³⁺	fluorozirconate	bulk	166
2.25–2.50	Tm ³⁺	fluorozirconate	fiber	180
2.27–2.40	Tm ³⁺	fluorozirconate	fiber	28
~2.3	Tm ³⁺	fluorozirconate	fiber	112
2.3	Tm ³⁺	fluorozirconate	fiber	181
2.3	Tm ³⁺	fluorozirconate	fiber	182
2.35	Tm ³⁺	fluorozirconate	fiber	28
2.35	Tm ³⁺	fluorozirconate	fiber	165
2.65–2.77	Er ³⁺	fluorozirconate (Pr)	fiber	183
2.69–2.78	Er ³⁺	fluorozirconate	bulk	184
2.70	Er ³⁺	fluorozirconate	bulk	167
2.702	Er ³⁺	fluorozirconate	fiber	185,186
2.71	Er ³⁺	fluorozirconate	fiber	187
2.714	Er ³⁺	fluorozirconate	fiber	188
2.715(g)	Er ³⁺	fluorozirconate	fiber	163
2.716	Er ³⁺	fluorozirconate	fiber	189
2.75	Er ³⁺	fluorozirconate	fiber	187
2.78	Er ³⁺	fluorozirconate	fiber	187,190
2.83–2.95	Ho ³⁺	fluorozirconate	fiber	191
3.45	Er ³⁺	fluorozirconate	fiber	192
3.483	Er ³⁺	fluorozirconate	fiber	193
3.535	Er ³⁺	fluorozirconate	fiber	193
3.95(h)	Ho ³⁺	fluorozirconate	fiber	194

- (a) If a tuning range is reported, the laser is listed by the lowest wavelength cited.
- (b) Codopant and fluorescence sensitizing ions are included in parentheses.
- (c) Proof of lasing was based on the appearance of emission spikes.
- (d) Co-lasing at 1.55 μm .
- (e) Co-lasing at 1.88 μm .
- (f) Co-lasing at 2.7 μm .
- (g) Co-lasing at 1.7 μm .
- (h) Operates in cascade with simultaneous laser emission at $\sim 1.2 \mu\text{m}$.

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Section 2.3

SOLID STATE DYE LASERS

Introduction to the Table

Solid-state lasers based on organic dye molecules in various host materials are listed in order of increasing wavelength in [Table 2.3.1](#). Lasers that have been tuned over a range of wavelengths are listed by the lowest wavelength reported; the tuning range given is that for the experimental configuration and conditions used and may not represent the extremes possible. The dye molecule and host material are listed together with the primary reference to laser action. The references should be consulted for details of the chemical composition and molecular structure of the dyes and host compounds.

The lasing wavelength and output of dye lasers depend on the characteristics of the optical cavity, the dye concentration, the optical pumping source and rate, and other operating conditions. The original references should therefore also be consulted for this information and its effect on the lasing wavelength.

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Table 2.3.1
Solid State Dye Lasers Arranged in Order of Increasing Wavelength

Wavelength (nm)	Dye (a)	Host (b)	Reference
376	4-phenylstilbene	naphthalene (4.2 K)	1
376	Exalite 377E	silica	2
381–394	BBQ	polystyrene	3
383	diphenylbutadiene (DPB)	para-terphenyl	4
385	1-(2-naphthyl)-2-phenylethylene	naphthalene (4.2 K)	1
~395	α -NPO	polyisobutylmethacrylate	5
395	$\beta\beta$ -dinaphthylethylene ($\beta\beta$ -DNE)	naphthalene	6,7
395	β -naphthyl-p-biphenylethylene (β -BNE)	naphthalene	7
396	α -NPO	PMMA	8
396	diphenylbutadiene (DPB)	para-terphenyl	7
397	1,2-di(2-naphthyl)ethylene	naphthalene (4.2 K)	1
397	1-(1-naphthyl)-2-(2-naphthyl)ethylene	naphthalene (4.2 K)	1
397	1-(4-biphenyl)-2-(2-naphthyl)ethylene	naphthalene (4.2 K)	1
398	azulene	naphthalene (4.2 K)	1
400	2-(4-biphenyl)-5-(p-styrylphenyl)-1,3,4-oxadiazole	PMMA	8
403	LD 390	silica	2
408–410	anthracene	2,3-dimethylnaphthalene	9
408–410	anthracene	dibenzofurane	9
408–410	anthracene	fluorene	1,9,10
408–410	anthracene	sym-octahydroanthracene	9
410	2-(4-biphenyl)-5-(1-naphthyl)oxazole	PMMA	8
~410	POPOP	polyisobutylmethacrylate	5
411	a-NPO	polystyrene	8

414	5-phenyl-2-(p-styrylphenyl)oxazole	PMMA	8
414	dimethyl-POPOP	polystyrene	8
415	1-styryl-4-[1-(2-naphthyl)]vinylbenzene	naphthalene (4.2 K)	1
415	POPOP	PMMA	8
416	2-(1-naphthyl)-5-styryl-1,3,4-oxadiazole	PMMA	8
416–426	POPOP	polystyrene	3
418	1,2-di-4-biphenylethylene	diphenyl (4.2 K)	1
418	2-phenyl-5-[p-(4-phenyl-1,3-buladrenyl)phenyl]-1,3,4-oxadiazole	PMMA	8
~420	dimethyl-POPOP	polyisobutylmethacrylate	5
420	POPOP	polystyrene	8
422	1,4-bis(2-naphthyl)styrylbenzene	naphthalene (4.2 K)	1
423	dimethyl-POPOP	PMMA	8
424	dimethyl-POPOP	polystyrene	8
425	2-[p-[2-(2-naphthyl)vinyl]phenyl]-5-phenyloxazole	PMMA	8
425	dimethyl-POPOP	polyvinylxylene	8
426–445	dimethyl-POPOP	polystyrene	3
427	dimethyl-POPOP	polystyrene	8
428	5-phenyl-2-[p-(-phenylstyryl)phenyl]oxazole	PMMA	8
428–438	dimethyl-POPOP	polystyrene	11
~430	BBOT	polyisobutylmethacrylate	5
433–457	coumarin 1	silica gel	12
437	β -naphthyl-p-biphenylethylene (β -BNE)	dibenzyl	7
440	stilbene	silica	80
440–472	BBOT	polystyrene	3
441	pyrene	K ₂ SO ₄ crystal	13

Table 2.3.1—continued
Solid State Dye Lasers Arranged in Order of Increasing Wavelength

Wavelength (nm)	Dye (a)	Host (b)	Reference
442	1-styryl-4-[1-(2-naphthyl)vinyl]benzene	naphthalene (4.2 K)	1
443	5-(4-biphenyl)-2-[p-(4-phenyl-1,3-bis(4-vinylphenyl)phenyl)oxazole	PMMA	8
443.9	coronene	methyl-cyclohexane/isopentane	14
444	1,2-bis(5-phenyloxazolyl)ethylene	PMMA	5
449	1,4-bis(2-naphthyl)styrylbenzene	naphthalene (4.2 K)	1
450	1,5-diphenyl-3-styryl-2-pyrazoline	PMMA	8
450–540 ^(c)	methylumbelliferone	Knox ^(d) gelatin	15
~453 ^(c)	7-diethylamino-4-methylcoumarin	Knox ^(d) gelatin	15
455	1,4-bis[4-[5-(4-biphenyl)-2-oxazolyl]styryl]benzene	PMMA	8
455–475	perylene	PMMA(BBOT) ^(e)	16
457	3-p-chlorostyryl-1,5-diphenyl-2-pyrazoline	PMMA	8
~460	coumarin 460	PBD	90
461	β -naphthyl-p-biphenylethylene (β -BNE)	dibenzyl	7
464–480	BBOT + perylene	polystyrene	3
468–494	coumarin 460	silica	17
469	POPOP	durol	7
475	coumarin 460	silica	80
478	(see Ref. 8)	PMMA	8
480	2-[p-[2-(9-anthryl)vinyl]phenyl]-5-phenyloxazole	PMMA	8
484–529	CF ₃ -coumarin	PMMA	18
487–495	coumarin 102	silica gel	12
490–500	1,3-dimethylisobenzofuran	polystyrene	3
490–500	acridine yellow	PMMA(coumarin 1) ^(f)	16

497	COP-2(g)	MMA 20	
493	2-(2'-hydroxy-5'-fluorophenyl) benzimidazole	PMMA	19
494	tetracene	dibenzyl (4.2 K)	1
494	5(6)-methoxycarbonyl-2(2'-hydroxyphenyl)benzimidazole	PMMA	20
498–574	coumarin 153	silica gel (ORMOSIL)	21
500–520	acriflavine	PMMA(coumarin 1) ^(f)	16
508	5(6)-methoxycarbonyl-12-(5'-fluoro-2'-hydroxyphenyl)benzimidazole	PMMA	20
509–514	fluoran	PMMA	8
511	COP-3(g)	MMA 20	
515	coumarin 540A	PMMA	76
521	tetracene	dibenzyl (4.2 K)	1
522	pyrromethene 567	HTP	22
525	coumarin 540A	silica gel (ORMOSIL)	23
525–650	rhodamine 6G	polyacrylamide gel	24
528	pyrromethene 597	HTP	22
528	naphthacene	para-terphenyl	7
530	tetracene	para-terphenyl	9
530–560	uranine	PMMA(coumarin 1) ^(f)	16
530–630	perylimide (BASF 241)	composite glass	25
535	coumarin 540A	P(HEMA:MMA 1:1)	76
535	coumarin 481	silica	79
541	pyrene	K ₂ SO ₄ crystal	14
542–606	pyrromethene 567	ORMOSIL (VTEOS, MTEOS)	26
543–603	pyrromethene 567	ORMOSIL (VTEOS, MTEOS)	27
545–572	coumarin 153	silica gel	12

Table 2.3.1—continued
Solid State Dye Lasers Arranged in Order of Increasing Wavelength

Wavelength (nm)	Dye (a)	Host (b)	Reference
545–630	rhodamine 6G	silica	28–30
549	pyrromethene 567	silica	31,83
550	rhodamine 6G	PMMA	8
550–570	pyrromethene 580	HTP	33
550–570(c)	Na fluorescein	Knox ^(d) gelatin	15
552–595	rhodamine 6G	PMMA	33,34
553–564	fluorescein (sodium salt)	polystyrene	11
554–584	pyrromethene 580	ORMOSIL (VTEOS, MTEOS)	26
555–565	rhodamine 6G	PMMA	36
556	pyrromethene 567	sol-gel glass	83
557	coumarin 540A	aluminosilicate	23,35
557–598	rhodamine RG6	silica gel (ORMOSIL)	21
558	coumarin 521	silica	80
559–587	rhodamine RG6	silica gel (ORMOSIL)	21
560	rhodamine 6G	silica	37
~560(h)	rhodamine 6G	Al ₂ O ₃	38
560–570	rhodamine 6G	mPMMA	39
560–570	rhodamine 6G chloride	mPMMA	40
560–570	rhodamine 6G percholate	mPMMA	40
560–570	rhodamine III	mPMMA	40
560–570	dye "II B"	mPMMA	40
562–590	rhodamine 6G	silica (ORMOSIL)	41

564	pyrromethene 567	acrylic copolymer	94
564	rhodamine 590	silica	31,83
565–590	pyrromethene 597	HTP	32
565.1	rhodamine 6G	PSI-gel	42
565.5	rhodamine 6G	PMMA	42
566.3	pyrromethene 570	HTP	42
567–594	perylene orange	ORMOSIL (VTEOS, MTEOS)	27
567–605	rhodamine 6G	PMMA	43
568	rhodamine 6G	silica (ORMOSIL)	23
568	rhodamine 6G	P(HEMA:MMA 1:1)	78
568	rhodamine 590	sol-gel glass	83
568–583	Lumogen LFO240	silica film (ORMOSIL)	17
569.6	pyrromethene 570	PMMA	42
569.7	1,3,5,7,8-pentamethyl-2,6-di-n-butylpyrromethene-BF ₂	MMA ⁽ⁱ⁾	44
570	DCM	PMMA	45
570	rhodamine 6G	aluminosilicate	23,35
570	pyrromethene 580	acrylic copolymer	46
570–610	rhodamine 6G	silica gel	47,86
570–620 ^(c)	rhodamine 6G	Knox ^(d) gelatin	16
570.9	rhodamine 6G	PMMA	42
571	pyrromethene 580	acrylic copolymer	95
571.0	1,3,5,7,8-pentamethyl-2,6-di-n-butylpyrromethene-BF ₂	MMA ⁽ⁱ⁾	44
571.4	pyrromethene 567	MMA ⁽ⁱ⁾	44
572	pyrromethene 567	ORMOSIL (silica/PMMA)	31
572	pyrromethene 567	polycom glass ^(m)	83

Table 2.3.1—continued
Solid State Dye Lasers Arranged in Order of Increasing Wavelength

Wavelength (nm)	Dye (a)	Host (b)	Reference
572(563)	rhodamine 590	polycom glass ^(m)	83
572	rhodamine 590	ORMOSIL (silica/PMMA)	31
573	rhodamine 590	PMMA	31,83
573	rhodamine 590 chloride	polycom glass ^(m)	83
574–606	pyrromethene 597	ORMOSIL (VTEOS, MTEOS)	26
575–590	BASF-241	ORMOSIL (silica/PMMA)	48
575–590	PPV7	PBD	91
577	rhodamine 6G	silica	37
577–590	rhodamine 6G	PMMA	49
578	perylene orange	PMMA	31
578	perylene orange	ORMOSIL (silica/PMMA)	31,50
578	perylene orange (KF 241)	ORMOSIL (silica/PMMA)	31,83
578	perylene orange (KF 241)	polycom glass ^(m)	83
580–620	rhodamine 6G	PHEMA+DEGMA	51
582–592	perylene orange	ORMOSIL (VTEOS, MTEOS)	26
584	rhodamine 6G	P(HEMA:MMA 3:7)	78
584	pyrromethene 567	ORMOSIL	46
585	perylene orange	silica	31,83
585	rhodamine 590	PMMA	52
585–606	ASPI	silica-MMA	85
587	pyrromethene 597	acrylic copolymer	46,94
587	pyrromethene 597	high temperature plastic	93
587	rhodamine-Bz-MA	P(HEMA:MMA 1:1)	77

587	rhodamine 6G	P(HEMA:MMA 7:3)	78
587.4	rhodamine B	PMMA	53
589	diphenylbutadiene (DPB)	para-terphenyl	7
589	POPOP	para-terphenyl	7
589	Cl-POPOP	para-terphenyl	7
589	rhodamine-Al	P(HEMA:MMA 1:1)	77
589–635 ⁽ⁿ⁾	DCM	Alq ₃	96
~590 ^(h)	rhodamine B	Al ₂ O ₃	38
590.7–654.3	DCM	ORMOSIL (TiO ₂)	82
593	PM-HMC	high temperature plastic	22
593	rhodamine-Bz-MA	P(HEMA:MMA 7:3)	77
593	rhodamine 6G	P(HEMA:MMA 1:1)	78
594.0	rhodamine B	PMMA	53
595	rhodamine C	PMMA	8
595–620	rhodamine	K ₂ SO ₄ crystal	13
595–640	perylene red	ORMOSIL (VTEOS, MTEOS)	26
595–644	perylene red	ORMOSIL (VTEOS, MTEOS)	27
595–650	DCM	ORMOSIL (film)	54
598	PM-TEDC	HTP	21
599	rhodamine 6G	P(HEMA:EDGMA 9:1)	78
~600	sulforhodamine B	acrylic monomers	55
~600	rhodamine 640	polystyrene	57
~600	ASPT	HEMA	87
~600	DCM II	PBD	90

Table 2.3.1—continued
Solid State Dye Lasers Arranged in Order of Increasing Wavelength

Wavelength (nm)	Dye (a)	Host (b)	Reference
~600–620 ^(c)	rhodamine B	Knox ^(d) gelatin	15
600–620	rhodamine B	PMMA(rhodamine 6G) ^(f)	16
600–625	rhodamine B	silica (ORMOSIL)	41
600–650 ^(j)	Wratten ^(d) 22 filter	————	15
600–650	sulforhodamine 640	silica gel	57
601.0	rhodamine 6G	PMMA	58
604	perylene red	ORMOSIL (silica/PMMA)	31
604	perylene red (KF 856)	polycom glass ^(m)	83
~605	MEH-PPV	PS:TiO ₂	92
605	rhodamine 6G	ORMOSIL (silica/GPTA)	53
605–630	Lumogen LFR300	silica film (ORMOSIL)	17
605–630	red perylimide dye	ORMOSIL (silica/PMMA)	49
605–648	sulforhodamine 640	silica gel	59
~606	DHASI	HEMA	98
609	rhodamine 640	pig fat	60
~610	ASPI ^(k)	PHEMA	81
610–620	rhodamine B	Al ₂ O ₃ (rhodamine 6G) ^(f)	61
610–620	rhodamine B	silica gel	12
610–635	rhodamine 6G	polyurethane	62–64
613	perylene red	PMMA	31,83
613	rhodamine 640	chicken tissue	60
613	DCM II	Alq ₃	88

614	perylene red	ORMOSIL (silica/PMMA)	50,83
614–624	rhodamine 6G	polystyrene	11
~615	DCM II	NAPOXA	90
615–629	Lumogen LFR300	silica film (ORMOSIL)	9
615–635	PM-TEDC	HTP	32
615–635	PM-HMC	HTP	32
617.9	1,3,5,7-tetramethyl-8-cyanopyrromethene-2,6-dicarboxylate-BF ₂	MMA ⁽ⁱ⁾	44
618.2	sulforhodamine B	MMA ⁽ⁱ⁾	44
620–640	oxazine-17	mPMMA	39,40
620–640	cresyl violet	PMMA (rhodamine 6G) ^(f)	16
620–670	sulforhodamine 101	PMMA (rhodamine 6G) ^(f)	16
624	PM650	HTP	46
625	coumarin 560	silica	80
~628	rhodamine B	silica (ORMOSIL- γ -GLYMO	66
~630	rhodamine 6G	gelatin	67
632.4	rhodamine B	PMMA	58
632.8	rhodamine B	polyurethane (film)	68
~640 ^(h)	oxazine 4	Al ₂ O ₃	38
643	rhodamine 110	polyurethane	69
645	DCM	Alq ₃	89
654	rhodamine 640	HEMA/MMA copolymer	70
~655	DCM	Alq ₃	97
655	coumarin 640	silica	80
657	Wratten ^(d) 29 filter	————	15
670	cresyl violet 670	polyimide (Probimide 414) ^(l)	84
680	indodicarbocyanine (PK 643)	polyurethane	71

Table 2.3.1—*continued*
Solid State Dye Lasers Arranged in Order of Increasing Wavelength

Wavelength (nm)		Dye (a)	Host (b)	Reference
680–746	Nile Blue		silica (ORMOSIL)	72
695–720	Nile Blue		PMMA (rhodamine 6G) ^(f)	16
727–747	LD800		ORMOSIL	73
~805	LDS821		PBD	90
819–844	HITC		ORMOSIL	73
845–865	HITC		PMMA (rhodamine 6G/nile blue) ^(f)	16

Footnotes – Table 2.3.1

- (a) See M. Maeda, *Laser Dyes*, Academic Press, New York (1984), Steppel, R. N., Organic Dye Lasers, in *Handbook of Laser Science and Technology, Vol. I: Lasers and Masers*, CRC Press, Boca Raton, FL (1982), p. 299, and Steppel, R. N., Organic Dye Lasers, in *Handbook of Laser Science and Technology, Suppl. 1: Lasers*, CRC Press, Boca Raton, FL (1991), p. 219 for complete compositions and chemical structures of the dyes.
- (b) Host materials: Alq₃ — tris-(8-hydroxyquinoline) aluminum, DEGMA — ethylene glycol dimethacrylate, EGDMA—ethylene glycol dimethacrylate, GLYMO — γ glycidyoxypropyl trimethoxy silan, GPTA — glycerol propoxy triacrylate, HEMA — hydroxy ethyl methacrylate, HTP — high temperature plastic (Korrr Electronics), MMA — methylmethacrylate, mPMMA — modified polymethylmethacrylate, MTEOS — methyl-triethoxysilane, NAPOXA — 2-naphthyl-4,5-bis(4-methoxyphenyl)-1,3-oxazole, ORMOSIL - organically modified silicate, PBD — 2-(4-biphenyl)-5-(4-*t*-butylphenyl)-1,3,4-oxadiazole, PHEMA — poly (2-hydroxyethyl methacrylate), PMMA — polymethylmethacrylate, PS — polystyrene, PSI — proprietary polymer, VTEOS — vinyltriethoxysilane.
- (c) Lasing wavelengths were not given but were stated to be close to those produced by the same dyes in liquid solutions.
- (d) Knox and Wratten are commercial product names.
- (e) Optical gain was also reported in Ref. 16 for 3-carboethoxy-7-hydroxycoumarin, 3-*n*-butyl-4-methyl-7-hydroxycoumarin, 4,6-dimethyl-7- ethylaminocoumarin, 4-methyl-7-dimethylaminocoumarin, 4-MU, and DAM-coumarin dyes in PMMA but no wavelengths were given.
- (f) Host materials were polymethylmethacrylate and polyvinylalcohol. Dyes in parentheses serve as a donor dye in an energy transfer laser.
- (g) See Ref. 20 for molecular structure of copolymer.
- (h) This is the wavelength of the fluorescence peak; lasing wavelengths were not cited.
- (i) 16% hydroxypropyl acrylate/methyl methacrylate.
- (j) Output was stated to be in the orange-red region.
- (k) ASPI—trans-4-[p-(N-hydroxyethyl-N-methylamino)styryl]-N-methylpyridinium iodide.
- (l) A photosensitive benzophenone tetracarboxylic diahydride-alkylated diamine polyimide.
- (m) Sol-gel glass–PMMA composite.
- (n) Laser emission varied by changing the thickness of the active organic layer.
- (o) Tb³⁺ laser action (~545 nm) from terbium thenoyltrifluoroacetate in PMMA was reported in Ref. 74, but no wavelengths were given.
- (p) Eu³⁺ laser action (~613 nm) from europium tris[4,4,4-trifluoro-1-(2-thienyl)-1,3 butanedione in PMMA was reported in Ref. 75, but no wavelengths were given.

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Section 2.4

COLOR CENTER LASERS

Introduction to the Table

Color center lasers are listed in order of increasing wavelength in [Table 2.4.1](#). The host crystal and the active center are given in the next two columns. If the host contained additives, they are listed following the colon. Lasers that have been tuned over a range of wavelengths are listed in order of the lowest wavelength reported; the tuning range given is that for the configuration and conditions used and may not represent the extremes possible.

The lasing wavelength and output power of color center lasers depend on the characteristics of the optical cavity, the temperature, the optical pump source, and other operating conditions. The original references should therefore be consulted for this information and its effect on the lasing wavelength.

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Table 2.4.1
Color Center Lasers Arranged in Order of Increasing Wavelength

Wavelength (μm)	Active center	Host crystal	Temperature (K)	Reference
0.357–0.420 ^(a)	F^+	CaO	77	1
0.51–0.57	F_3^+	LiF	300	2
0.519–0.722	F_3^+ , F_2 , unknown	LiF	300	58,60
0.52–0.56	F_3^+	LiF	300	50
0.53 ^(a)	H_3	C(diamond)	300	3
0.54–0.62	unknown	Al_2O_3	300	4,5,6,7
0.543	F_3^+	LiF	300	56
0.66	$(\text{F}_2)\text{A}$	$\text{MgF}_2:\text{Na}^+$	300	8,9,10
0.67	F_2	LiF	300	11
0.67–0.71	F_2	LiF	300	55
0.76	$(\text{F}_2)\text{A}$	$\text{CaF}_2:\text{Na}^+$	300	8,9,10
0.77–0.93	unknown	Al_2O_3	300	4,5,6,7
0.82–1.05	F_2^+	LiF	77	12,13,14
0.830–1.060	F_2^+	LiF	300	57
0.84–1.10	F_2-F_2^+	LiF	300	15
0.84–1.13	F_2^+	LiF:OH	300	52
0.85–1.040	F_2^+	LiF	300	51
0.89	$(\text{F}_2)\text{A}$	$\text{SrF}_2:\text{Na}^+$	300	8,9,10
0.85–0.96	unknown	$\text{KMgF}_3:\text{Pb}^{2+}$	77	16,17
0.86–1.02	F_3^-	LiF	300	18
0.94–1.06	unknown	$\text{KMgF}_3:\text{Cu}^+$	77	17
0.95–1.15	unknown	Al_2O_3	300	4,5,6,7
0.98–1.3	$(\text{F}_2^+)\text{A}$	$\text{NaF}:\text{Li}^+$	300	19
0.99–1.22	F_2^+	NaF	77	20
1.03–1.12	$(\text{F}_2^+)^*$	$\text{NaF}:\text{Mg}^{2+}$	77	21,22
1.09–1.24	F_2^-	LiF	300	15,53
1.10–1.30	F_2^+	NaF	77	23
1.150–1.172	F_2^-	LiF	300	59
1.23–1.35	N_2	KCl	77	24
1.24–1.45	F_2^+	KF	77	25

Table 2.4.1—continued
Color Center Lasers Arranged in Order of Increasing Wavelength

Wavelength (μm)	Active center	Host crystal	Temperature (K)	Reference
1.37–1.77	F_2^+	$\text{NaCl}:\text{OH}^-$	300	26,61
1.40–1.56	F_2^+	NaCl	77	27
1.40–1.60	$\text{F}_\text{A}:\text{Ti}^0(1)$	$\text{KCl}:\text{Ti}$	77	28,29
1.41–1.81	$\text{F}_2^+:\text{O}^{2-}$	$\text{NaCl}:\text{OH}^-$	77	30,31
1.42–1.76	$\text{F}_2^{+::}\text{O}^{2-}$	$\text{NaCl}:\text{K}^+$	77	32
1.43–2.00	$\text{F}_2^+:\text{S}^{2-}$	NaCl	77	33
1.450–1.600 ^(b)	$(\text{F}_2^+)\text{H}$	$\text{NaCl}:\text{OH}^-$	30	34
1.464–1.590	$\text{Ti}^0(1)$	$\text{NaCl}:\text{Ti}^+$	77	35
1.479–1.705	$(\text{F}_2^+)\text{H}$	$\text{NaCl}:\text{OH}^-$	<185	35
1.488–1.538	$\text{Ti}^0(1)$	$\text{KCl}:\text{Ti}^+$	84	36
1.493–1.540	$\text{Ti}^0(1)$	$\text{NaCl}:\text{Ti}^+$	77	35
~1.575	$(\text{F}_2^+)\text{H}$	$\text{NaCl}:\text{OH}^-$	77	54
1.61–1.77	F_2^+	KCl	77	27
1.62–1.91	$(\text{F}_2^+)\text{A}$	$\text{KCl}:\text{Na}^+$	77	37
1.66–1.97	$\text{F}_2^+:\text{O}^{2-}$	KCl	77	38
~1.71–2.15	$\text{F}_2^+:\text{O}^{2-}$	$\text{KCl}:\text{Na}^+$	77	39
1.73–2.10	$(\text{F}_2^+)\text{AH}$	$\text{KCl}:\text{Na}^+$	77	40
1.80–2.16	F_2^+	$\text{KBr}:\text{O}_2^-$	77	41
1.86–2.16	F_2^+	$\text{KBr}:\text{O}_2^-$	77	38
1.86–2.10	$(\text{F}_2^+)\text{H}$	$\text{KBr}:\text{O}_2^-$	77	42
1.96–2.35	$(\text{F}_2^+)\text{AH}$	$\text{KBr}:\text{Na}^+:\text{O}_2^-$	77	42
2.00–2.50	$(\text{F}_2^+)\text{A}$	$\text{KCl}:\text{Li}^+$	77	43
2.22–2.75	$\text{F}_\text{B}(\text{II})$	$\text{KCl}:\text{Na}^+$	77	44,45
2.30–3.10	$\text{F}_\text{A}(\text{II})$	$\text{KCl}:\text{Li}^+$	77	45
2.38–3.99	$(\text{F}_2^+)\text{A}$	$\text{KI}:\text{Li}^+$	77	46
2.48–3.64	$\text{F}_\text{A}(\text{II})$	$\text{RbCl}:\text{Li}^+$	77	45
4.86	CN^-	KBr	1.7	47
4.86	CN^-	KBr	1.7	46
4.88–5.00	$\text{F}_\text{H}(\text{CN}^-)$	CsCl	77	49

(a) Laser action requires further verification.

(b) Emission of the (a) variety of $(\text{F}_2^+)\text{H}$ center.

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Section 2.5

SEMICONDUCTOR LASERS

Introduction to the Tables

Semiconductor lasers are listed in order of increasing wavelength in [Table 2.5.1](#). Lasers that have been tuned over a range of wavelengths are listed by the lowest lasing wavelength reported; the tuning range given is that for the configuration and conditions used and may not represent the extremes possible. The lasing material, structure and operating configuration, method of excitation, and temperature are also given. If the operation was both pulsed (p) and continuous wave (cw), then the first temperature given is for pulsed operation and the second for continuous wave operation. Only inorganic semiconducting materials are listed in [Table 2.5.1](#). Dye-doped organic semiconductor lasers are included in [Table 2.3.1](#); semiconducting polymer lasers are covered in Section 2.6.

The lasing wavelength and output of semiconductor lasers depend on the chemical composition of the material, structural configuration, optical cavity, temperature, excitation rate, and other operating conditions. The original references should therefore be consulted for this information and its effect on the lasing wavelength.

Abbreviations used in the table to describe the laser structure and operation:

BGSL—broken-gap superlattice	BH—buried heterostructure
cw—continuous wave	DFB—distributed feedback
DH—double heterostructure	DQW—double quantum well
GRIN—graded index	H—heterostructure
J— <i>p-n</i> junction	ML—monolayer
MQW—multiple quantum well	p—pulsed
QB—quantum box	QC—quantum cascade
QD—quantum dot	QW—quantum well
RW—ridge waveguide	SL—superlattice
SB-BGSL — strain-balanced BGSL	SL-MQW—strained-layer MQW
SCBH—separate confinement buried heterostructure	SLS—strained-layer superlattice
SCH—separate confinement heterostructure	SQW—single quantum well
T2QWL — type II quantum well laser	SSQW—strained SQW
VCSEL—vertical cavity surface emitting laser	VC—vertical cavity

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Table 2.5.1
Semiconductor Lasers Arranged in Order of Increasing Wavelength

Wavelength (μm)	Material	Structure	Excitation	Temp. (K)	Ref.
0.3245–0.3300	ZnS	crystal	electron beam (p)	4.2, 77	1
0.33	ZnS	crystal	electron beam (p)	80	2
0.333	CdZnS/ZnS	QW	optical (p)	8	274
0.3497	ZnS	crystal	optical (p)	300	3
~0.356	GaN	SCH QD	optical (p)	20	4
0.357–0.390	CdZnS/ZnS	SLS MQW	optical (p)	300	273
~359	GaN/AlGaN	DH	optical (p)	77	243
0.359	GaN	crystal	optical (p)	2	5
~0.3615	GaN/AlGaN	SCH	optical (p)	300	6
0.362–0.381	GaN	crystal	optical (p)	10–375	7
0.3635	GaN/AlGaN	VCSEL	optical (p)	300	8
~365	GaN/AlGaN	DH	optical (p)	295	243
0.3696	GaN	layer	optical (p)	300	10
0.3749	CdZnS/ZnS	SLS	optical (p)	300	271
0.375–0.400	ZnO	crystal	optical (p)	80–300	11
0.3755	CdZnS/ZnS	SLS MQW	injection (p)	30	273
0.3757	ZnO	crystal	electron beam (p)	77	12
0.376	GaInN	SQW SCH	injection (p)	300	199
0.376–0.378	GaN	layer VC	optical (p)	300	13,14
0.378	GaN	film	optical (p)	300	15
~0.38	ZnO	film	optical (p)	300	16
~0.385	GaN	ML	optical (p)	300	293

0.385	InGaN/GaN	MQW	optical (p)	≤ 220	17
0.387	GaN/AlGaN	H	optical (p)	34	294
0.389–0.399	AlGaN/GaInN	DFB DH	optical (p)	300	295
0.3914	CuCl	crystal QD	optical (p)	77–108	298
0.399–0.402	InGaN	MQW	injection (p, cw)	300	291
0.4025	AlGaN/GaInN	DH	optical (p)	300	19
0.40583	InGaN	MQW	injection (cw)	300	20
0.406	InGaN	ML VC	optical (p)	300	296
0.407–0.411	InGaN	MQW	injection (p)	300	297
0.410	InGaN/InGaN	MQW	optical (p)	300	292
0.415	InGaN/GaN	VC	optical (p)	300	21
0.417	InGaN	MQW	injection (p)	300	22
0.419	InGaN	MQW	injection (p)	300	44
0.427–0.437	InGaN/GaN	MQW	optical (p)	175–575	50
0.430	ZnSe	crystal	optical (p)	≤ 200	23
~0.438	ZnSSe	crystal	opt., elect. beam (p)	≤ 200	23
~0.445–0.455	ZnSe/ZnSSe	SL	optical (p)	14–180	24
0.445	ZnSe/ZnSSe	H	optical (p)	< 400	272
0.4496–0.624	CdSSe	crystal	optical (p)	77	25
~0.453	ZnSe/ZnMnSe	MQW	optical (p)	5.5–80	26
0.454–0.474	ZnSe/ZnSSe	SL	electron beam (p)	100	9
0.460	ZnSe	crystal	electron beam (p)	100	27
0.462	ZnSe/ZnSSe	H	optical (p)	≤ 260	28

Table 2.5.1—continued
Semiconductor Lasers Arranged in Order of Increasing Wavelength

Wavelength (μm)	Material	Structure	Excitation	Temp. (K)	Ref.
0.463	ZnSe/ZnMgSSe	SCH	injection (p)	300	267
0.4647–0.4663	CdSe/ZnSe	SL	optical (p)	80	29
0.468	(Zn,Cd)Se/ZnSe	MQW	optical (p)	300	30
0.469	ZnSe	crystal	optical (p)	300	31
0.469–0.475	ZnSe	crystal	optical (p)	300	32
0.474	ZnSe/ZnSSE	SL	electron beam (p)	100	9
0.4784	ZnCdSe/ZnSe	GRINSCH	electron beam (p)	83–225	33
0.480–0.500	(Zn,Cd)Se/ZnSe	MQW	injection (p)	≤ 250	34
0.485	CdZnSe	SQW	electron beam (p)	~20	290
~0.49	CdS	crystal	electron beam (p)	90, 300	35
0.490	CdZnSe	SQW	injection (p)	77	38
0.490–0.512	CdZnSe/ZnSe	QW	injection (cw)	80	39
0.49–0.56	ZnCdTe/ZnSe	SQW	optical (p)	300	36
0.49–0.69	CdSSe	crystal	electron beam (p)	4.2, 77	37
0.491	CdS	crystal	electron beam (p)	4.2, 77	40
0.492	(Zn,Cd)Se/ZnSe	SQW	optical (p)	10	41
~0.494	(Zn,Cd)Se/Zn(S,Se)	MQW	injection (p)	≤ 300	43
0.4943	CdS	crystal	optical (p)	88	43
0.495–0.520	CdS	crystal	optical (p)	90–300	11
0.496	(Zn,Cd)Se	SCH VCSEL	optical (p)	300	45
0.496	ZnCdSe/ZnSSe/ZnMgSSe	SCH	injection (cw)	85	269
0.496, 0.502	CdS	crystal	optical (p)	77	46

0.4963	(Zn,Cd)Se/ZnSe	SQW	optical (p)	150	41
0.4966	CdS	crystal	electron beam (p)	4	48
0.498–0.517	(Zn,Cd)Se/ZnSe	MQW	optical (p, cw)	300–10	49
0.50	(Zn,Cd)Se/ZnSe	SQW	optical (p)	250	41
0.504	ZnCdSe/ZnSSe	MQW	optical (p)	300	51
0.507	BeZnCdSe/BeZnSe/BeMgZn Se	SCH	injection (p)	77	268
0.508–0.535	CdZnSe/ZnSe	QW	injection (cw)	300	39
0.512	ZnCdSe/ZnCdMgSe	GRINSCH SQW	optical (p)	300	53
0.516	ZnCdSe/ZnSSe/ZnMgSSe	SCH	injection (p)	300–394	269
0.520	ZnCdSe/ZnSSe/ZnMgSSe	SCH	injection (p)	300	54
0.5235	ZnCdSe/ZnSSe/ZnMgSSe	SCH	injection (p)	300	270
0.528	ZnTe	crystal	electron beam (p)	4	55
0.533	ZnTe	crystal	electron beam (p)	110	56
0.549–0.562	InGaP	crystal	electron beam (p)	10–150	57
0.5520	InGaP:N	crystal	injection (cw)	77	58
0.575–0.602	CdZnTe/ZnTe	SLS QW	optical (cw)	8–310	59
0.5762–0.5845	GaInP/AlInP	MQW	injection (p)	109–165	60
0.580–0.705	CdSSe	crystal	optical (p)	90–300	11
0.5836	AlGaInP	DH	injection (cw)	77	62
0.585–0.620	ZnCdSe	crystal	electron beam (p)	10–310	64
0.59–0.60	GaSe	crystal	electron beam (p)	77	65
0.59–0.60	GaSe	crystal	optical (p)	77	66
0.6010	GaSe	crystal	optical (p)	2	67,68

Table 2.5.1—*continued*
Semiconductor Lasers Arranged in Order of Increasing Wavelength

Wavelength (μm)	Material	Structure	Excitation	Temp. (K)	Ref.
0.602–0.604	GaSe	crystal	optical (p)	5	69
0.607	GaInP/AlInP	SSQW DFB	injection (p)	140	70
0.615	AlGaAs/InGaP	H	injection (cw)	300	71
0.615	AlGaAs/InGaP	H	injection (cw)	300	71
0.621	AlGaInP	mesa stripe	injection (cw)	273	72
0.625	InGaAlP	MQW	injection (cw)	300	73
0.6262	AlGaInP/AlGaInP	DH	injection (p)	300	74
0.627–0.640	GaInP/GaAlInP	SQW GRINSCH	injection (p)	300	75
0.63–0.65	InGaAlP	H	injection (cw)	295–323	76
~0.636	AlGaAs/AlGaAs	H	optical (p)	300	77
0.6378	InGaAlP	SBR	injection (cw)	298	78
0.640	AlGaInP	H	injection (cw)	293	79
~0.640	In(Al,Ga)P	MQW H	optical/injection (cw)	300	80
0.670–0.690	AlGaInP/AlGaAs	VCSEL QW	injection (cw)	300	81
0.671	GaInP/AlGaInP	DH	injection (cw)	293	82
0.674–0.681	AlGaAs/GaAs	SL QW RW	injection (cw)	300	83
0.680–0.700	AlGaAs	DH	injection (cw)	300	84
0.680–0.785	GaAs/GaAlAs	SL SQW GRINSCH	injection (p, cw)	300	85,86
~0.685	CdSe	crystal	electron beam (p)	4.2	40
0.688–0.729	AlGaAs	H	injection (p,cw)	100	88

0.6897	AlGaInP/GaInP/AlGaInP	DH	injection (cw)	300	89
0.69–0.79	GaAs	SL QW	injection (cw)	300	83
0.6917	CdSe	crystal	optical (p)	77	90
0.695	InGaP	crystal	optical (p)	77	91
0.696–0.760	AlGaAs	layer	electron beam (p)	81	92
0.697	CdSe	crystal	optical (p)	77	93
0.698–0.752	CdSe	crystal	optical (p)	90–300	11
0.7010	GaAsP/InGaP	H	injection (cw)	283	95
0.704	GaAsP	crystal	electron beam (p)	77	96
0.707	InAlAs	QD H	injection (cw)	77	97
0.710	GaAsP	J	injection (p)	77	98
0.750	AlGaAs	H	injection (p)	77, 273	99
0.750–0.855	AlGaAs/GaAs	GRINSCH SQW	injection (cw)	300	100
0.761, 0.763	InGaP	J	injection (p)	4.2, 77	101
0.765	CdIn ₂ S ₄	crystal	optical (p)	100–300	102
0.77	CdSiAs ₂	crystal	electron beam (p)	77	103
0.770	AlGaAs	SL VCSEL	injection (cw)	300	104
0.7812	GaAs/AlGaAs	DH	injection (p)	77	105
~0.785	InGaPAs/GaAs	H	injection (cw)	300	108
0.785	CdTe	crystal	electron beam (p)	10–15	106,107
~0.800–0.845	AlGaAsP	DH	injection (p)	77–300	109
0.808	InGaAsP/GaAs	SQW	injection (cw)	300	110
0.825	GaAs	SQW	injection (cw)	300	83
0.83	GaAs	crystal	optical (p)	300	111
0.83	InGaAsP/InGaP	QW H	injection (cw)	300	112

Table 2.5.1—*continued*
Semiconductor Lasers Arranged in Order of Increasing Wavelength

Wavelength (μm)	Material	Structure	Excitation	Temp. (K)	Ref.
0.8365	GaAs	crystal	optical (p)	77	113
0.837–0.843	GaAs	H	injection (p)	4.2, 77	114
~0.84	GaAs	crystal	electron beam (p)	4	115–117
~0.84–0.86	GaAs/InAs	SCH SSQW	optical (p, cw)	77	118
0.8404	GaAs/AlGaAs	SCH	injection (cw)	300	94
0.842	GaAs	J	injection (p)	77	120
0.843	GaAs	H	injection (p)	77	121
0.843–0.8562	GaAlAs/GaAs	SH	injection (cw)	77	122
0.844–0.852	AlGaAs	H	injection (p)	77, 300	123
0.845	AlGaAs	H	injection (cw)	100	88
0.845	GaAs	crystal VCSEL	injection (cw)	300	125
0.850	InP	crystal	optical (p)	77	126
0.87	GaAs	DH	injection (cw)	300	83
~0.900–0.962	GaAs	VCSEL	injection (cw)	300	127
0.906–0.908	InP	crystal	injection (p)	4, 77	128,129
0.911	InGaAs	QD	injection (p)	80	130
0.915	InP	crystal	optical (p)	300	131
0.935	InGaAs	crystal	optical (p)	300	131
0.942, 0.945	InSe	crystal	optical (p)	5	69
~0.945–0.985	InSe	crystal	optical (p)	20, 90	133
0.9604	InAlGaAs	QD VCSEL	injection (cw)	300	134
0.97	InSe	crystal	electron beam (p)	90	135

~0.978–0.984	InGaAs/GaAs/InGaP	RW QW	injection (cw)	300	136
0.979	InGaAs	SQW	injection (cw)	300	137
0.980	GaAsSb/AlGaAsSb	DH	injection (p)	300	138
0.982–0.992	InAs	GRINSCH QB	injection (cw)	79	139
0.99	InGaAs/GaAs	SL QW	injection (cw)	300	140
1.00–1.05	InAs/GaAs	SCH QD	injection (cw)	100–300	142
1.008	AlGaInAs/AlInAs	DH	injection (p)	300	143
1.011	CdSnP ₂	crystal	electron beam (p)	80	145
1.028	InGaAs/GaAs	SI SCH QD	injection (cw)	300	146
1.074	InGa/GaAs	SL QW BH	injection (p)	300	144
1.10–1.60	AlGaSb	crystal	electron beam (p)	83	147
1.17–1.26	InGaNaS/GaInP	DH	optical (p)	300	282
1.17–1.26	InGaNaS/GaInP	DH	optical (p)	300	178
1.27	InGaAsP/InP	DH	injection (p)	300	148
1.3	AlGaInAs	MQW VCSEL	injection (cw)	300	149
1.31	InGaAsP/InP	BH	injection (p)	30	150
1.440–1.640	InGaAs/InP	MQW GRINSCH	injection (cw)	300	151
1.5	InGaAs/InGaAsP	SL-MQW	injection (cw)	283–373	47
1.5–1.6	InGaAs/InAlAs	MQW	injection,optical (p)	300	152
1.51–1.53	GaSb	crystal	electron beam (p)	4, 20	153
1.541	GaSb	crystal	optical (p)	4	154
1.55	InGaAsP	QW VC	injection (p)	300	155
1.55–1.60	GaSb	J	injection (p)	78	141

Table 2.5.1—continued
Semiconductor Lasers Arranged in Order of Increasing Wavelength

Wavelength (μm)	Material	Structure	Excitation	Temp. (K)	Ref.
1.57	GaSb	J	injection (p)	77	156
1.60	In ₂ Se	crystal	electron beam (p)	90	157
1.602	InPAs	crystal	optical (p)	77	158
1.62	InGaAs/InP	SQW GRINSCH	injection (cw)	300	159
1.77, 2.07	InGaAs	J	injection (cw)	1.9	160
1.89–1.97	HgCdTe	MQW SCH	optical (p)	300–10	277
1.9–2.5	HgCdTe	MQW GRINSCH	optical (p)	300	262
2	AlGaAsSb/InGaAsSb	SQW	injection (cw)	283–288	289
~2.0	GaInAsSb/GaSb	DH	injection (cw)	80	161
2.0–2.2	HgCdTe	SCH	optical (p)	150–300	276
2.023	InGaAsSb/AlGaSb	DH	injection (p)	140, 300	162
2.06–2.3	HgCdTe	MQW GRINSCH	optical (p)	300–10	277
2.1	GaInAsSb/AlGaAsSb	DH	injection (p,cw)	300, 190	163
~2.12	Cd ₃ P ₂	crystal	optical (p)	4.2	164
2.18–2.5	HgCdTe	MQW SCH	optical (p)	300–10	277
~2.2	GaInAsSb/AlGaSb	DH	injection (p, cw)	303	165
2.2	InGaAsSb/AlGaSb	DH	injection (p)	300	162
2.36	HgCdTe/CdTe	MQW SCH	optical (p)	12, 77	167
2.5	HgCdTe	DH	optical (p)	110	263
2.7	InAs/GaInSb/InAs/AlGaInAsSb	SB-BGSL	injection (p)	180	279
2.7	InGaAsSb/AlGaAsSb	MQW	injection (cw)	170–234	283

2.7–3.2	InAs	film	electron beam (p)	80–220	168
2.7–3.9	InAsSb(P)/InAsSbP	DH	injection (cw)	80	169
2.7–6.6	PbEuSeTe	DH	injection (cw)	≤ 147	170
2.77–3.14	PbSrS/PbSrS	DH	injection (p)	180–90	179
2.79	HgCdTe	layer	optical (p)	~ 12	171
2.79–3.44	PbSrS/PbS	MQW	injection (p)	255–90	179
~ 2.8	HgCdTe	QW DH	optical (p,cw)	> 60	173
2.8	GaInSb/InAs	MQW BGSL	injection (p)	225	172
2.86	HgCdTe	DH	injection (p)	77	174
2.88	PbSe/PbEuSe	DH	injection (cw)	100	175
2.9	HgCdTe	DH	injection (p)	40–90	176,177
2.94	InAs	crystal	optical (p)	20	154
2.95–3.84	PbSrS/PbS	DH	injection (p)	250–90	179
2.97	PbSrS/PbS	DH	injection (p,cw)	245, 174	179
~ 3.0	InAs	crystal	optical (p)	4	180
3–3.3	HgCdTe	MQW GRINSCH	optical (p)	300–10	277
3.06	InGaAsSb/InPSb	DH	injection (p)	35	181
3.06–3.29	InAsSbP/InGaAsSb	DH	optical, (p, cw)	77	181
3.08–3.30	GaInAsSb/GaSb	DH	optical (p)	82–210	284
3.1	GaInSb/InAs	MQW	injection (p)	220	172
3.1	HgCdTe	DH	optical (p)	120	266
3.1	InAs/GaInSb	MQW	injection (p)	190	172
3.1	InAs/InAsSbP	DH	optical (p)	77–100	184
3.1	InAs/InAsSbP	DH	optical (p)	77–100	304

Table 2.5.1—continued
Semiconductor Lasers Arranged in Order of Increasing Wavelength

Wavelength (μm)	Material	Structure	Excitation	Temp. (K)	Ref.
3.112	InAs	J	injection (p)	4, 77	185
~3.17	InAsSb	crystal	injection (p)	77	186
~3.2	InAsSbP/InAsSb/InAs	DH	injection (p, cw)	220, 77	288
3.2	GaInSb/InAs	MQW	injection (p)	255	172
3.2	HgCdTe/CdZnTe	QW	optical (p)	80–154	275
3.2	InAs/GaInSb/InAs/AlSb	T2QWL	optical (p)	350	285
3.28–3.90	GaInSb/InAs	MQW	injection (p)	170–84	187
3.3–3.4	InAs/InAsSb	type-II SL	optical (cw)	95	188
3.39–3.58	HgCdTe	DH	optical (p)	78	278
3.4	GaInAs/AlInAs	MQW RW	injection (p, cw)	10–280, 10–50	63
3.4	GaInSb/InAs	MQW	injection (p)	195	172
3.4	HgCdTe	DH	injection (p)	40–90	176, 177
3.4	HgCdTe	DH	injection (p)	78	264
3.4	HgCdTe	SCH	optical (p)	90	265
3.4	InAs/GaInSb/InAs/AlSb	T2QWL	optical (p)	310	285
3.4–6.5	PbEuTe	DH	injection (p)	> 200	189
3.5	PbCdS	J	injection (cw)	10–20	190
3.5–3.6	InAsSb/	MQW DH	injection (p)	77–135	287
3.57–3.86	InAsSb/InAsP	SLS	optical (p)	80–240	191
~3.6	InAsSb	layer	optical (p)	77	184
~3.6	InAsSb/InAs	J	optical (p)	77	186

3.6	HgCdTe	layer	injection (p)	12–90	192
3.6	InAsSb/InAsSbP	DH	injection (cw)	77–100	286
3.7	InAs/GaInSb/InAs/AlGaInAsSb	SB-BGSL	optical (p)	300	279
3.79–3.8	InAs/(In)GaSb/(In)AlSb	QC type-II MQW	injection (p)	170	194
3.8–3.9	InAsSb/InAs	MQW H	injection (p)	210	195
3.86–3.97	InAsSb/GaSb	DH	optical (p)	80–150	284
~3.9	InAs(In)/GaSb/(In)AlSb	QC type-II MQW	injection (p)	40–170	124
3.9	AlGaSb/InAsSb/AlGaSb	DH	optical (p)	80–135	196
3.9	HgCdTe	DH	injection (p)	40–90	176,177
3.9	InAsSb/InAlAsSb	SQW	injection (p, cw)	165, 123	197
3.9	InAsSb/InAs	DH	optical (p)	77–125	304
3.9–4.1	InAs/GaInSb/InAs/AlSb	MQW	optical (p)	80–285	198
3.9–8.6	PbSSe	crystal	optical (p)	2	18
3.97	PbEuSeTe/PbTe	SQW	injection (p)	260	170,200
3.97–3.985	InAsSb/AlAsSb	DH	injection (p, cw)	155, 80	202
4.1	GaInSb/InAs	MQW	injection (p)	135	172
4.1	InAs/GaInSb/InAs/AlSb	T2QWL	optical (p)	285	198
4.19–6.49	PbEuSeTe/PbTe	SCBH	injection (cw)	215–20	280,281
4.2–4.5	InAs/GaInSb/InAs/AlSb	QC type-II QW	optical (p)	100–310	203
4.2–6.4	PbEuSeTe/PbTe	BH	injection (cw)	90–203	204
4.26	AlInAs/GaInAs	QC MQW	injection (p)	10–90	205
4.3	GaInSb/InAs	MQW	injection (p)	110	172
~4.3	PbS	crystal	electron beam (p)	4.2	206

Table 2.5.1—continued
Semiconductor Lasers Arranged in Order of Increasing Wavelength

Wavelength (μm)	Material	Structure	Excitation	Temp. (K)	Ref.
4.32	PbS	J	injection (cw)	4.2	207,208
4.40–6.50	PbGeTe	J	injection (cw)	4	209
4.4–8.0	PbSe/PbSrSe	H	injection (p, cw)	290, 169	210
4.41–6.45	PbEuSeTe/PbTe	SQW	injection (cw)	174–13	170,200
4.5362–5.7026	PbEuSeTe/PbTe	DH BH	injection (cw)	120–180	211
4.6	GaInAs/AlInAs	QC MQW RW	injection (p, cw)	10–200, 50–85	212
4.77–7.18	PbSnTe/PbEuSeTe	BHG	injection (cw)	20–175	213
~5	GaInAs/AlInAs	MQW RW	injection (p, cw)	10–320, 10–140	87,217-8
~5	GaInAs/AlInAs	QC MQW microdisk	injection (p)	10–150	52
5.085–5.28	InSb	J	injection (p)	10	215
5.1	InAlSb/InSb	H	injection (p)	≤ 90	216
5.16–5.32	InSb	crystal	optical (cw)	20	201
5.2	InAs/GaInSb/InAs/AlGaInAsS b	SB-BGSL	optical (p)	185	279
5.258	InSb	crystal	optical (p)	4	219
5.3	HgMnTe	H	injection (p)	77	220
5.31–5.38	GaInAs/AlInAs	MQW DFB	injection (p)	110–315	61
5.37–5.44	AlInAs/GaInAs	QC MQW DFB	injection (p)	170–300	183
~5.4	HgZnTe	layer	optical (p)	50–70	222
5.55–7.81	PbEuSe/PbSe/PbEuSe	BH	injection (p, cw)	30–160	223
5.7–7.8	PbSe/PbEuSe	DH	injection (p, cw)	220, 174	175

5.90–8.55	PbSnTe/PbTeSe	MQW	injection (p, cw)	~10–204	228
6	PbSnTe	MQW	injection (p, cw)	204, 130	229
6.1	PbSSe	SH DH	injection (cw)	12	230
6.2–6.6	AlInAs/GaInAs	MQW RW	injection (p)	10–280, 10–80	231
6.41	PbTe	crystal	electron beam (p)	4.2	206
6.5	PbTe	crystal	injection (p)	12	232
7.4–8.6	GaInAs/AlInAs	QC MQW RW	injection (p, cw)	210, 110	234
7.7	GaInAs/AlInAs	QC SL RW	injection (p)	10–240	235
7.78–7.93	GaInAs/AlInAs	MQW DFB	injection (p)	80–310	61
8.2–18.5	PbSnTe/PbTe	H	injection (cw)	12–80	225,236
~8.5	GaInAs/AlInAs	MQW RW	injection (p, cw)	10–320, 10–110	87,238
8.5	GaInAs/AlInAs	MQW RW	injection (p)	80–270	132
8.5	PbSe	crystal	electron beam (p)	4	206
8.5	PbSe	J	injection (p)	4	240
~9	PbSnTe/PbTeSe	BH	injection (cw)	80	239
~9.3	GaInAs/AlInAs	QC MQW RW	injection (p)	10–220, 1035	237
9.4	PbSnTe	J	injection (p,cw)	12	241
~9.5	GaInAs/AlInAs	QC microdisk	injection (p)	<140	242
10.2	PbSnSe	J	injection (p, cw)	77	241
~11.1	AlInAs/GaInAs	MQW RW	injection (p, cw)	10–200, 10–30	87,238
11.5	GaInAs/AlInAs	QC MQW microdisk	injection (p)	10	242
~12.5	GaAs/AlGaAs	QW	optical (p)	77	244
12.7	PbSnTe	J	injection (p, cw)	12	241
12.8	PbSnTe	DH	injection (p)	77–188	189
12.9	GaInAs/AlInAs	QC MQW RW	injection (p)	10–170	166

Table 2.5.1—*continued*
Semiconductor Lasers Arranged in Order of Increasing Wavelength

Wavelength (μm)	Material	Structure	Excitation	Temp. (K)	Ref.
13.7	PbSnTe	J	injection (p, cw)	12	241
75–130	Ge(Ga),Ge(Al)	crystal (parallelpiped)	elect./mag. fields (p)	4.2–18	245-256
75–250	Ge(Be),Ge(Zn)	crystal (parallelpiped)	elect./mag. fields (p)	4.2	224,226
80–150	Ge(Cu)	crystal (parallelpiped)	elect./mag. fields (p)	4.2	224,226- 27
85–110	Ge(Tl)	crystal (parallelpiped)	elect./mag. fields (p)	4.2	257
~100	Bi _x Sb _{1-x}	crystal (plate)	injection (cw)	4.2	258
110–360	Ge(Ga)	crystal (parallelpiped)	elect./mag. fields (p)	4.2	259-261
120–165	Ge(Tl)	crystal (parallelpiped)	elect./mag. fields (p)	4.2	257
170–250	Ge(Ga),Ge(Al)	crystal (parallelpiped)	elect./mag. fields (p)	4.2–18	245-256

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Section 2.6

POLYMER LASERS

Introduction to the Table

Lasers based on neat and dilute blends of conjugated polymers are listed in order of increasing wavelength in Table 2.6.1 (dye-doped polymer lasers are included in Table 2.3.1). Lasers that have been tuned over a range of wavelengths are listed by the lowest wavelength reported; the tuning range given is that for the experimental configuration and conditions used and may not represent the extremes possible. The lasing material, mode of photon confinement, and optical pumping wavelength are also listed together with the primary reference. The references should be consulted for details of the chemical composition and molecular structure of the lasing compounds. All experiments used pulsed excitation and were performed at room temperature. The reported observations may be indicative of lasing or amplified spontaneous emission.

Further Reading

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Abbreviations for the materials in Table 2.6.1:

BCHA	poly 2,5-bis(cholestanoxo)
BDOO-PF	poly(9,9-bis(3,6-dioxaoctyl)-fluorene-2,7-diyl)
BEH	poly 2,5-bis(2'-ethylhexyloxy)
BuEH	poly 2-butyl-5-2'-ethylhexyl
CB	chlorobenzene
CN-PPP	poly(2-(6'-methylheptyloxy)-1,4-phenylene)
DCM/PS	4-(dicyanomethylene)-2-methyl-6-(4-dimethylaminostyryl)-4H-pyran
DOO-PPV	2,5-dioctyloxy <i>p</i> -phenylene vinylene
HEH-PF	poly(9-hexyl-9-2'-ethylhexyl)-fluorene-2,7-diyl)
m-LPPP	methyl-substituted conjugated ladder-type poly(paraphenylene)
M3O	poly 2-methoxy-5-3'-octyloxy
MEH	poly 2-methoxy-5-2'-ethylhexyloxy

Abbreviations for the materials in Table 2.6.1—continued:

NAPOXA	2-naphthyl-4,5-bis(4-methoxyphenyl)-1,3-oxazole
PBD	2-(4-biphenyl)-5-(4- <i>t</i> -butylphenyl)-1,3,4-oxadiazole
PMMA	polymethylmethacrylate
PPPV	phenyl-substituted poly(<i>p</i> -phenylene vinylene)
PPV	poly(1,4-phenylene vinylene)
PS	polystyrene
Si-PPV	poly(dimethylsilylene- <i>p</i> -phenylene-vinylene)-(2,5-di- <i>n</i> -octyl- <i>p</i> -phenylene)-PPV
THF	tetrahydrofuran

Table 2.6.1
Polymer Lasers Arranged in Order of Increasing Wavelength

Wavelength (nm)	Material	Photon confinement	Pump (nm)	Ref.
392	PBD	waveguide	337	1
420*	CN-PPP	waveguide	355	2
425, 445*	HEH-PF	waveguide	355	2
430, 450, 540	BDOO-PF	waveguide	355	2
452	Si-PPV	waveguide	355	10
480–545	PPPV-PMMA	resonator	450	11
~483–492	m-LPPP	waveguide	444	3
520–620	BuEH-PPV	waveguide	310	4
530, 620*	M3O-PPV	waveguide	532	2
540–583	BuEH-PPV	waveguide (DFB)	435	5
540, 570 (Sh)*	BuEH-MEH(97.5:2.5)	waveguide	435	2
540, 630*	BCHA-PPV	waveguide	532	2
~545	PPV	microcavity	335	6
~545	PPV	microcavity	355	7
545, 580(Sh)*	BuEH-MEH(95:5)	waveguide	435	2
~550	BuEH-PPV	waveguide/microcavity	435	8
~550	BuEH-PPV	waveguide	435	2
550, 580(S2)*	BuEH-MEH(90:10)	waveguide	435	2
565, 600*	BuEH-MEH(70:30)	waveguide	532	2
580, 625*	BEH-PPV	waveguide	532	2
580, 625*	BuEH-MEH(10:90)	waveguide	532	2
585, 625*	MEH-PPV	waveguide	532	2
625	DOO-PPV	waveguide	532	9
640*	DCM/PS	waveguide	532	2

* Peak(s) of photoluminescence; lasing wavelength was not reported.

DFB – distributed feedback

Sh – shoulder

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