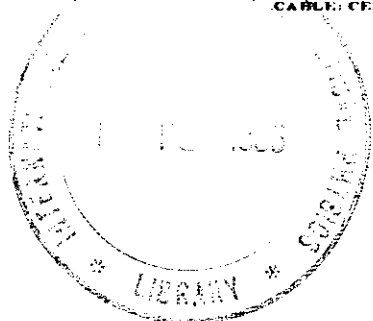




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SMR/115 - 25

WINTER COLLEGE ON LASERS, ATOMIC AND MOLECULAR PHYSICS

(21 January - 22 March 1985)

SOLID STATE LASERS

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These are preliminary lecture notes, intended only for distribution to participants.
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Elements of transition groups. Why?

$$\exp 2\sigma N_c l = 1/R_1 R_2 \quad N_c = \frac{-\ln R_1 R_2}{2\sigma l} = \gamma$$

$$W_{cf} N_g = N_c / \tau \quad W_{cf} = \frac{N_c}{N_g \tau} \propto \boxed{\frac{1}{\sigma \tau}}$$

$$\sigma \propto |\mu|^2 g_p \propto |\mu|^2 / \Delta \omega_0 \quad \tau = \phi \tau_{sp} \propto \phi |\mu|^2$$

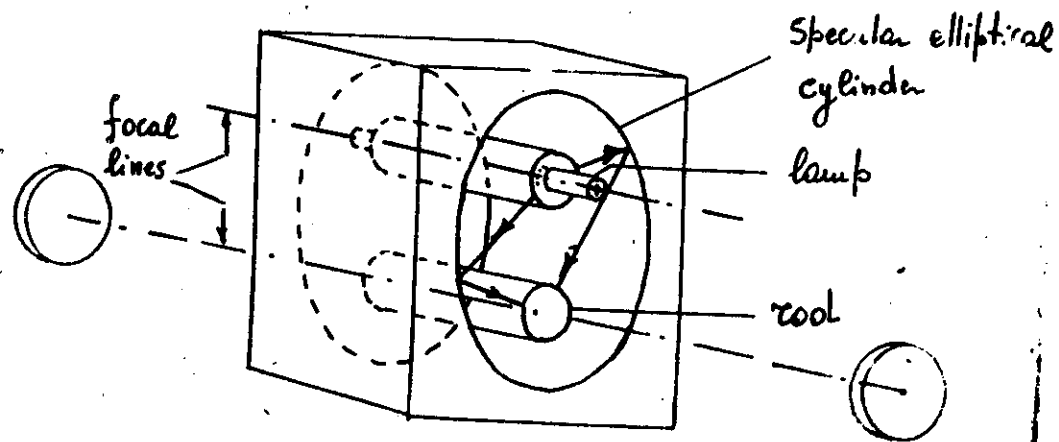
$$\sigma \tau \propto \phi / \Delta \omega_0$$

$$W_{cf} \propto 1/\sigma \tau \propto \Delta \omega_0 / \phi$$

- Transition metals $[Cr^{3+}, Co^{2+}, Ni^{2+} \dots]$

- Rare earths $[Nd^{3+}, Ho^{2+}, Er^{3+}]$

- Actinides $[U^{3+}]$



Rod diameter : 2-8 mm

Rod length : 5-10 cm

- Nd:YAG

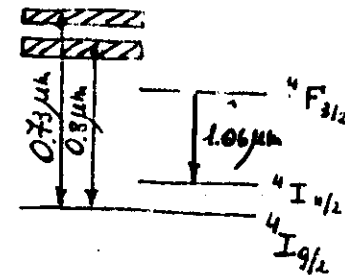
$$\lambda = 1.32 \mu\text{m}$$

$${}^4F_{3/2} \rightarrow {}^4I_{13/2} [{}^6E_2]$$

$$\lambda = 1.06 \mu\text{m}$$

$${}^4F_{3/2} \rightarrow {}^4I_{9/2} [{}^6E_2] \quad \sigma_2 = \sigma_3$$

Performances : 40 W CW at 1.32 μm !



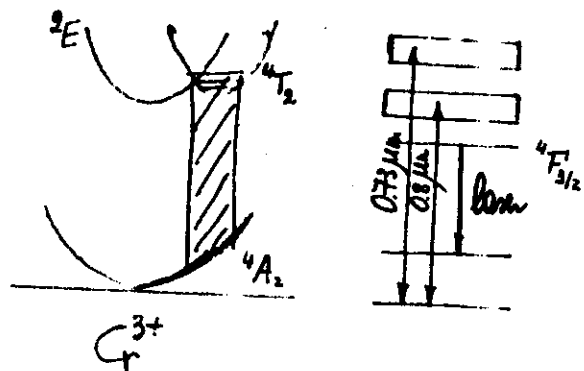
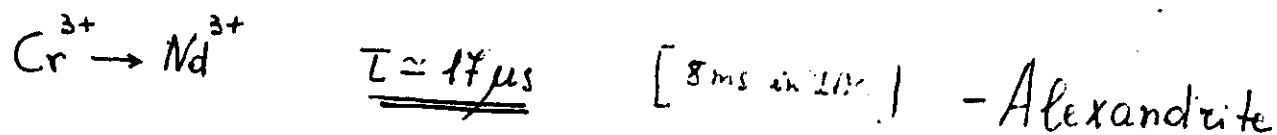
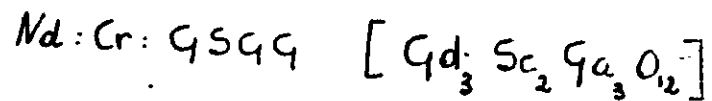
Applications of 1.32 μm beam : laser surgery, laser pumping

of divalent transition metals, testing of optical fibres

$\rightarrow \text{Ho}^{2+} : \text{YLF}$ (Erbium-Thulium sensitized Li:YF_4)

$\lambda = 2.06 \mu\text{m}$ 100 mJ, 100 Hz, 50 ns or CW

slope eff. 2% pulsed or 3.5% CW



Result of codoping: both Cr^{3+} and Nd^{3+}

absorption bands are useful for pumping $4F_{3/2} \Rightarrow$

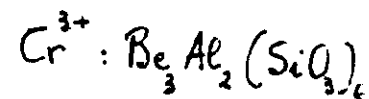
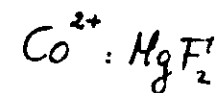
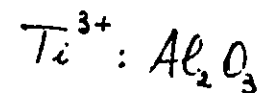
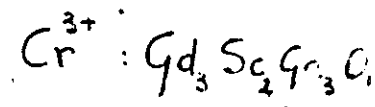
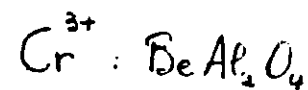
increase by a factor ~ 2 of slope-efficiency ($\sim 6\%$)

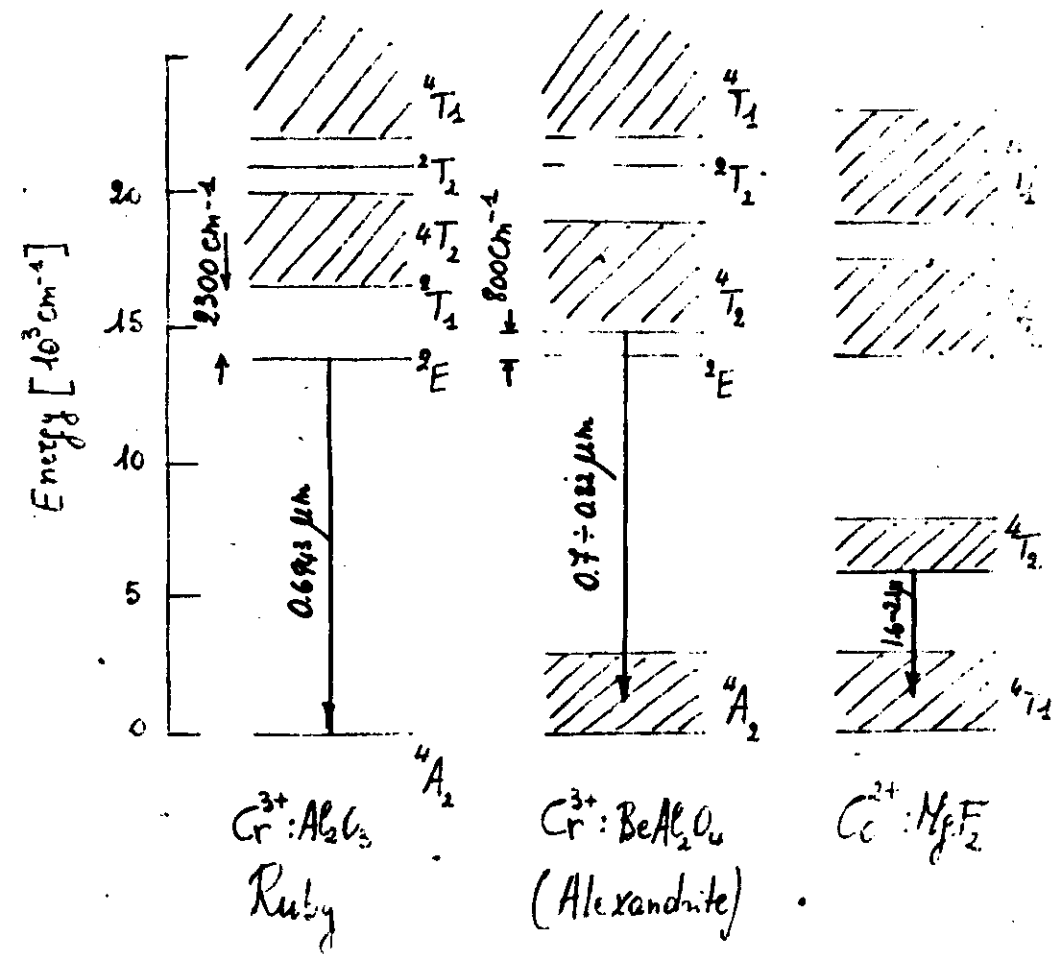
- Cr:GSGG

- Ti:sp/white

- Co: HgF_2

- Emerald





Material	σ [10^{-20} cm^2]	τ [ms]	λ [μm]	$\Delta\lambda$ [nm]
Ruby	9.5	3	0.694	0.53
Nd:YAG	35	0.23	1.06	0.73
Alexandrite	0.7	0.32	0.76	100
Co:MgF₂			1.9	80
Cr:GSGG		0.12	0.75	100
Emerald	1.4	0.07	0.75	80
Ti:sapphire	7	0.003	0.82	326

$$N_p = \gamma / \sigma l \quad P_{th} = \gamma A \hbar \omega / \sigma \tau_{sp} \eta_p$$

$$E_{th} = \gamma A \hbar \omega / \sigma \eta_p$$

Type	Pump	Operation	Slope efficiency	Output
Alexandrite	Flash lamp	Pulsed	4%	4 J x 25 Hz
"	Mercury arc	CW		50 W
Cr: GSGG	Ar or Kr lamp	CW		250 mW
Ti: Sapphire	Flash lamp*	Pulsed	1%	
Co: MgF ₂	1.32 μ m Nd:YAG	pulsed	33%	0.22 J x 20 Hz T = 230 °K
Emerald	Kr lamp	CW	34%	320 mW

* Fast flashlamp (~ 2 μ s) with Coumarin 480 as light converter.

- Material processing

- Spectroscopy

- Military applications

- LIDARS

- Photochemistry and isotope separ.

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