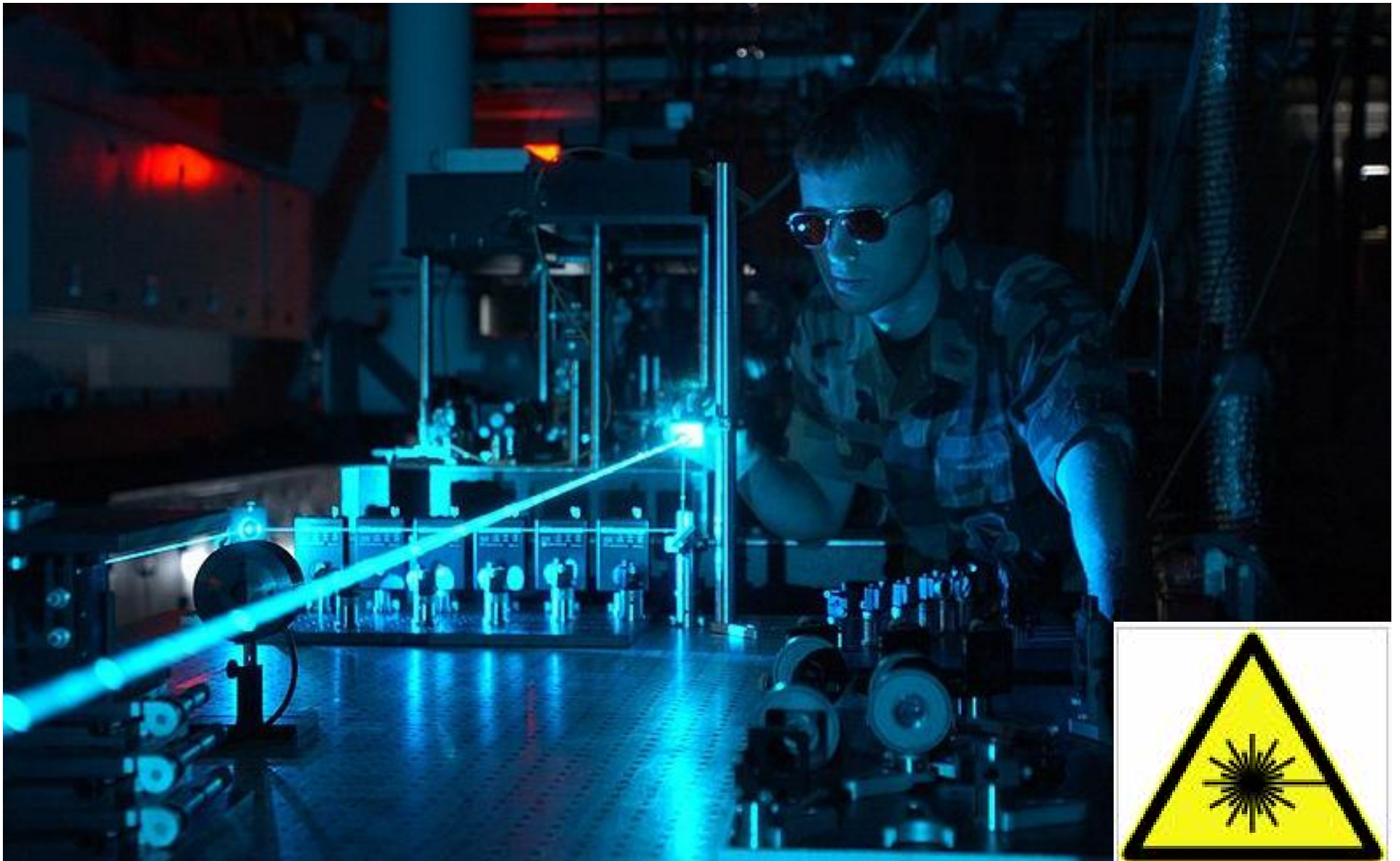


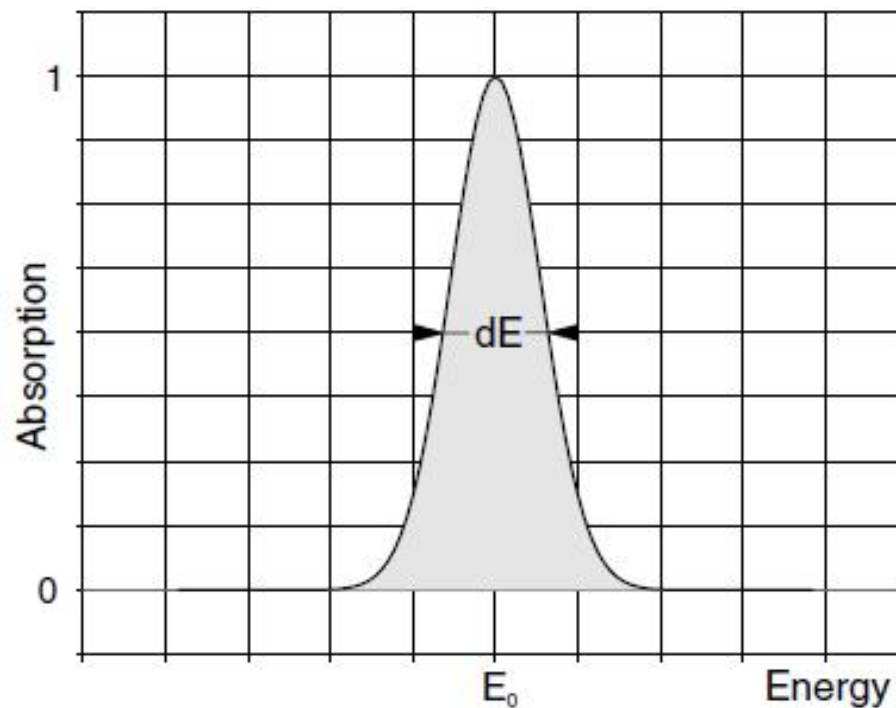
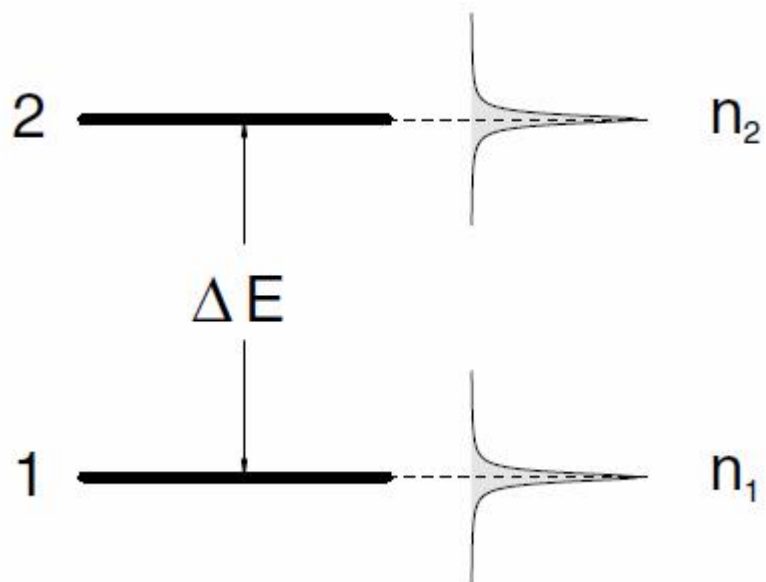
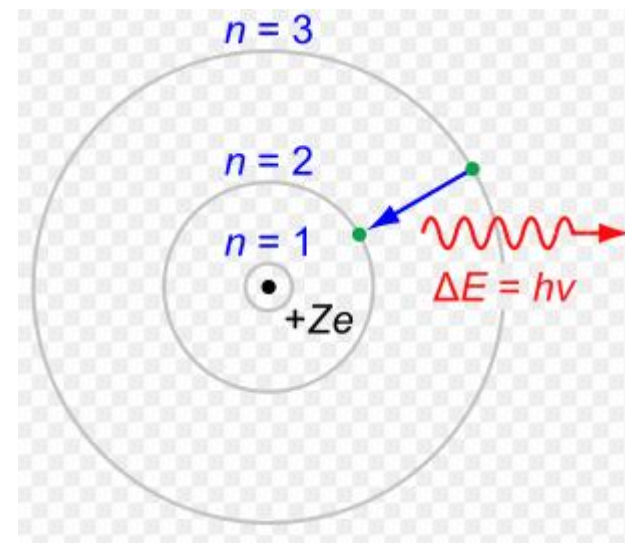
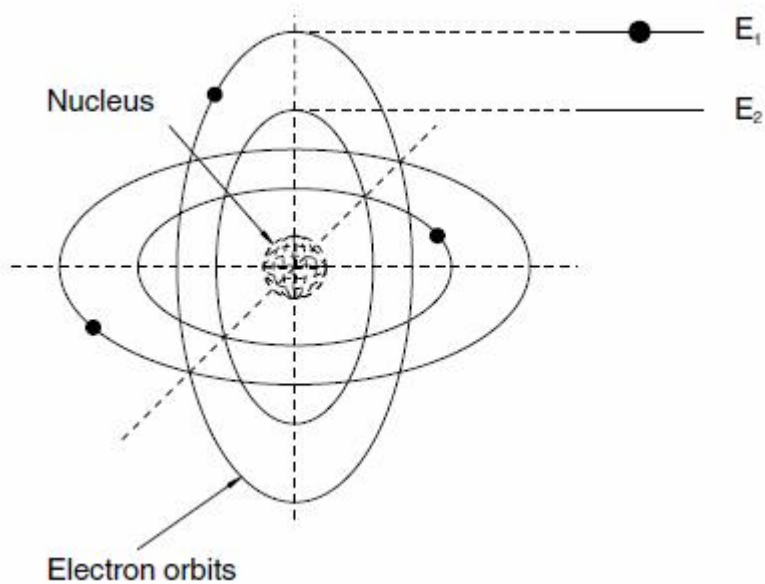
LASER

(**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation)

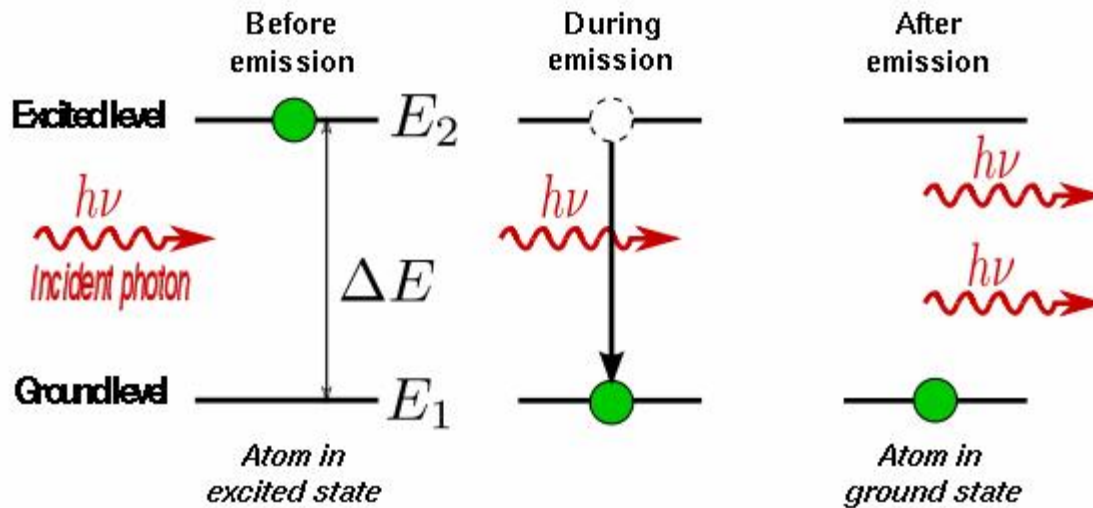
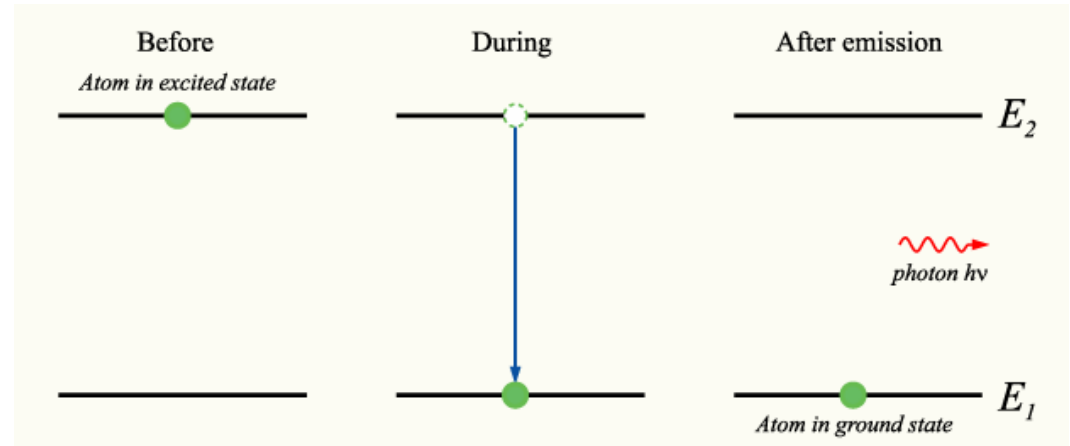
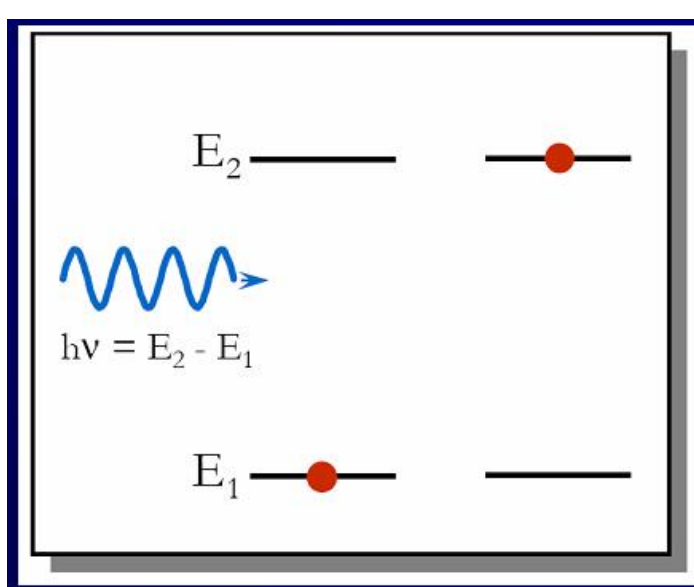




Класически представи за енергетичната структура на атома



Поглъщане / Излъчване / Стимулирано излъчване

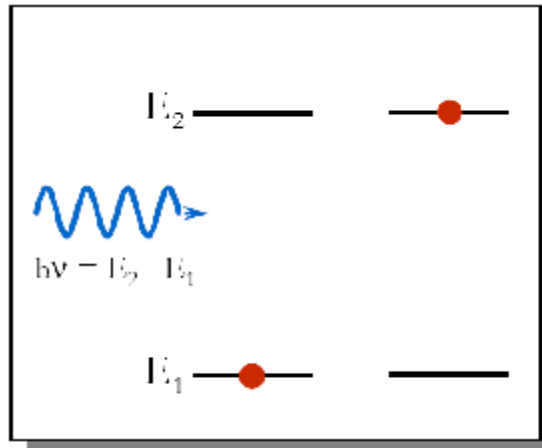


$$E_2 - E_1 = \Delta E = h\nu$$

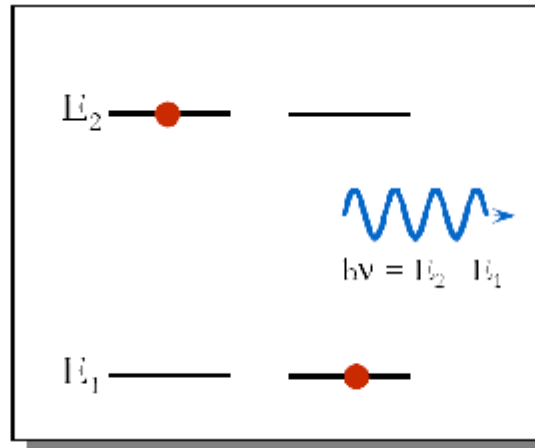
$$A_{ij} = \frac{8\pi h\nu^3}{c^3} B_{ij}$$

Принцип на действие на лазерите

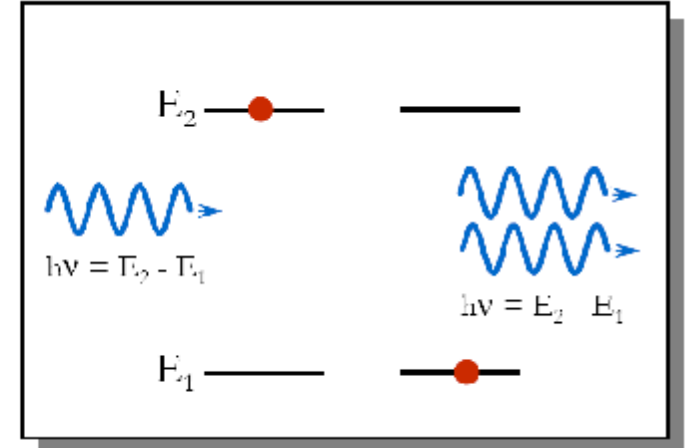
Основни процеси (А. Айнщайн, 1916г.)



Поглъщане

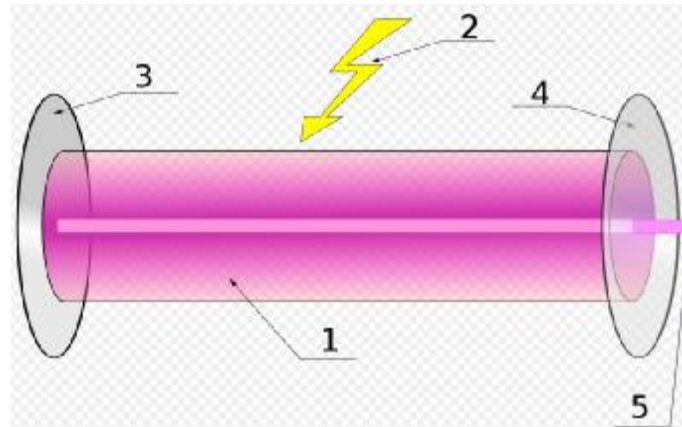


Спонтанно излъчване
(със случайна фаза
и посока)



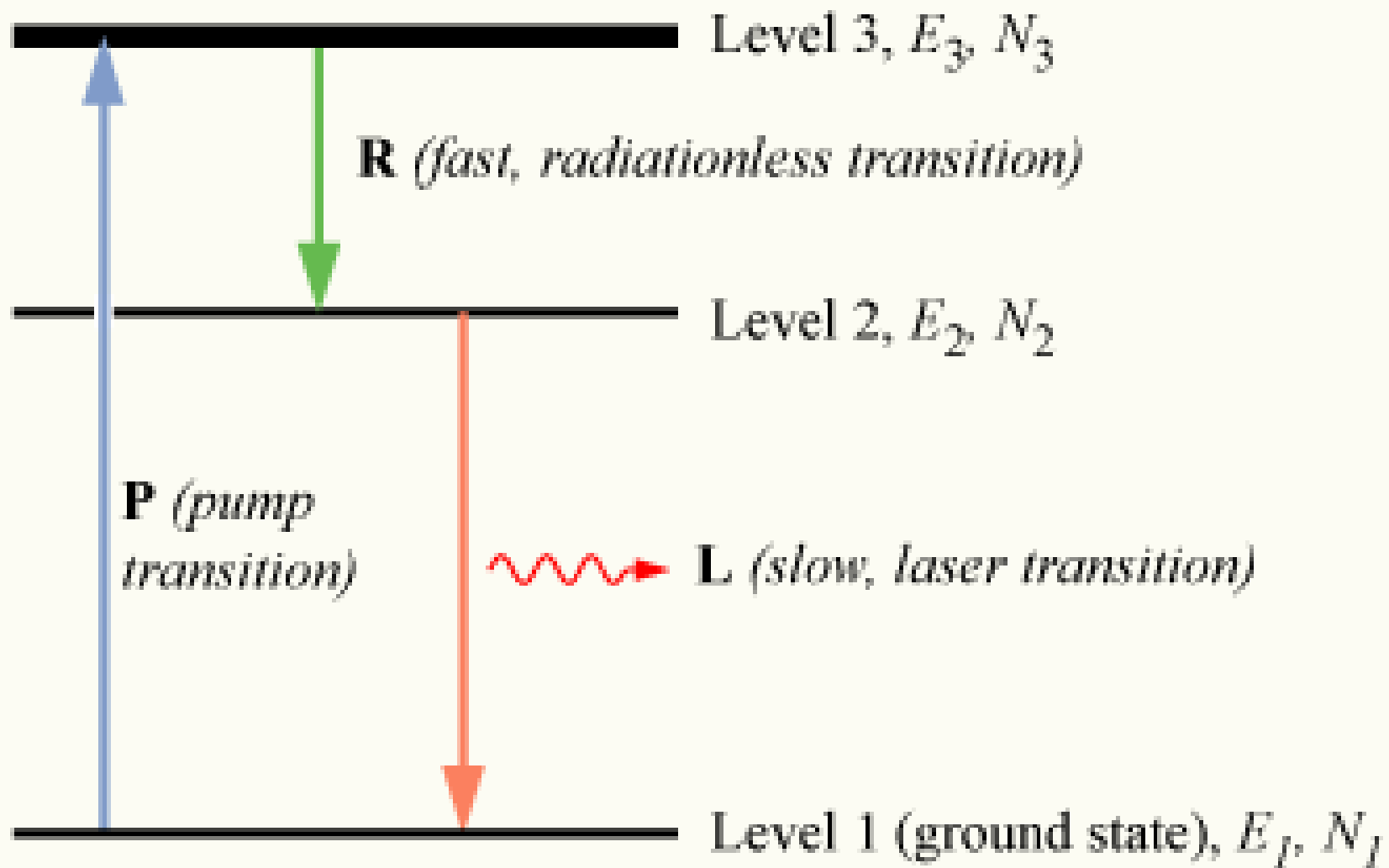
Стимулирано излъчване
(със същата честота и
фаза, както падащото
лъчение, т.е. усилване)

Условия за получаване на лазерна генерация

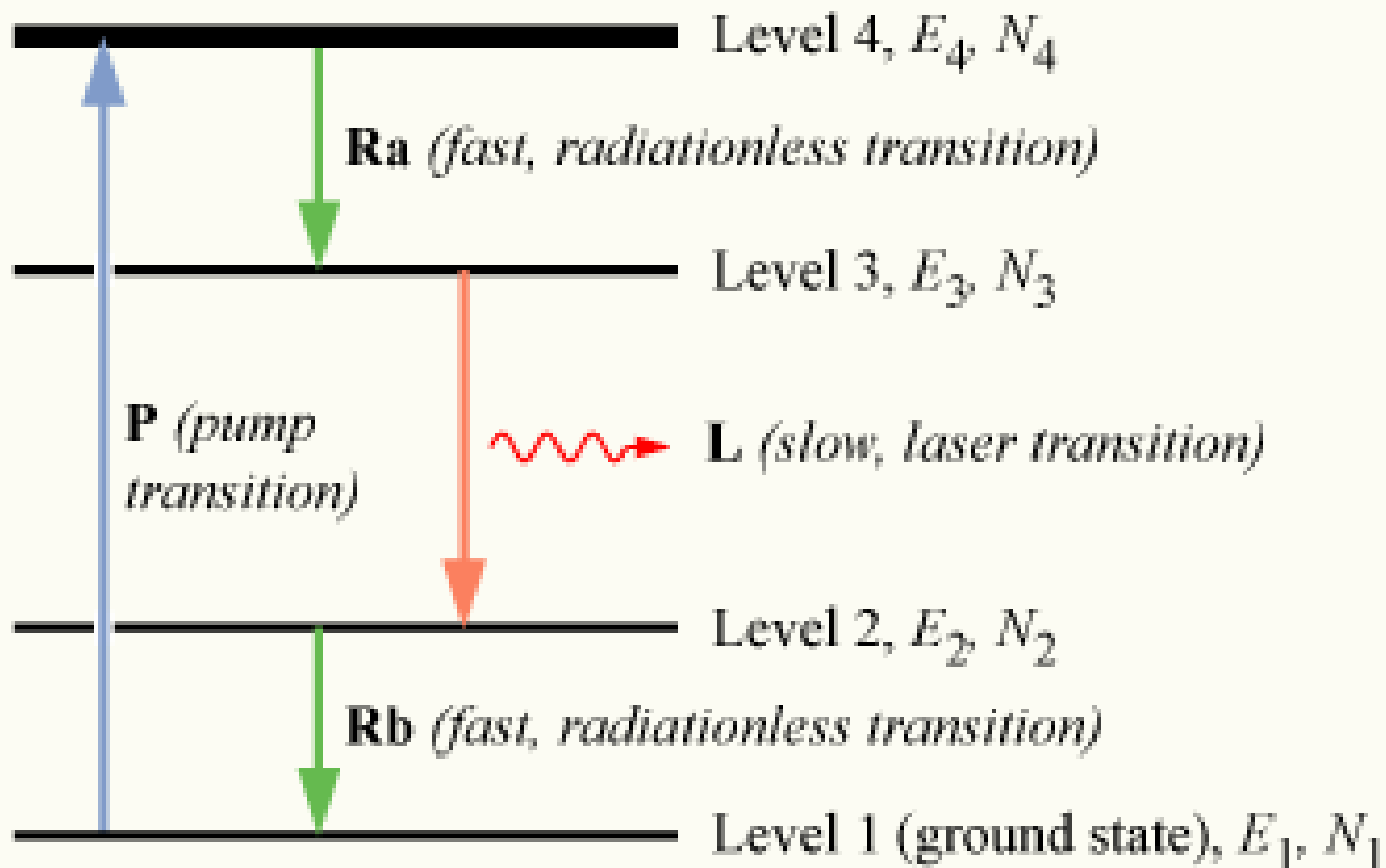


$$I/I_0 = R_1 R_2 \exp(2g_{\text{threshold}} l) \exp(-2\alpha l) = 1.$$

$$g_{\text{threshold}} = \alpha_0 - \frac{1}{2l} \ln(R_1 R_2).$$

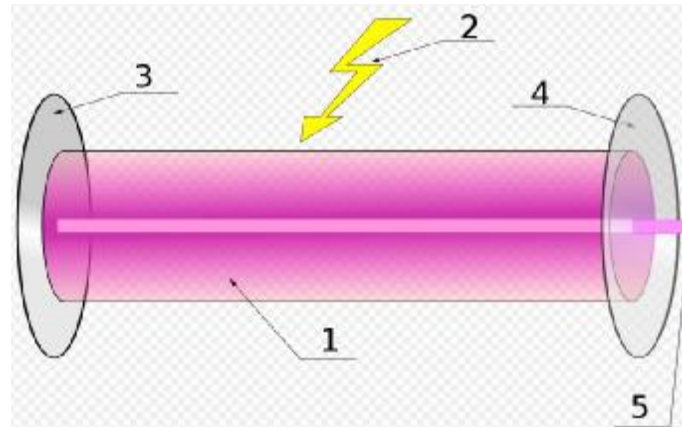


Диаграма на лазер с три работни нива.



Диаграма на лазер с четири работни нива.

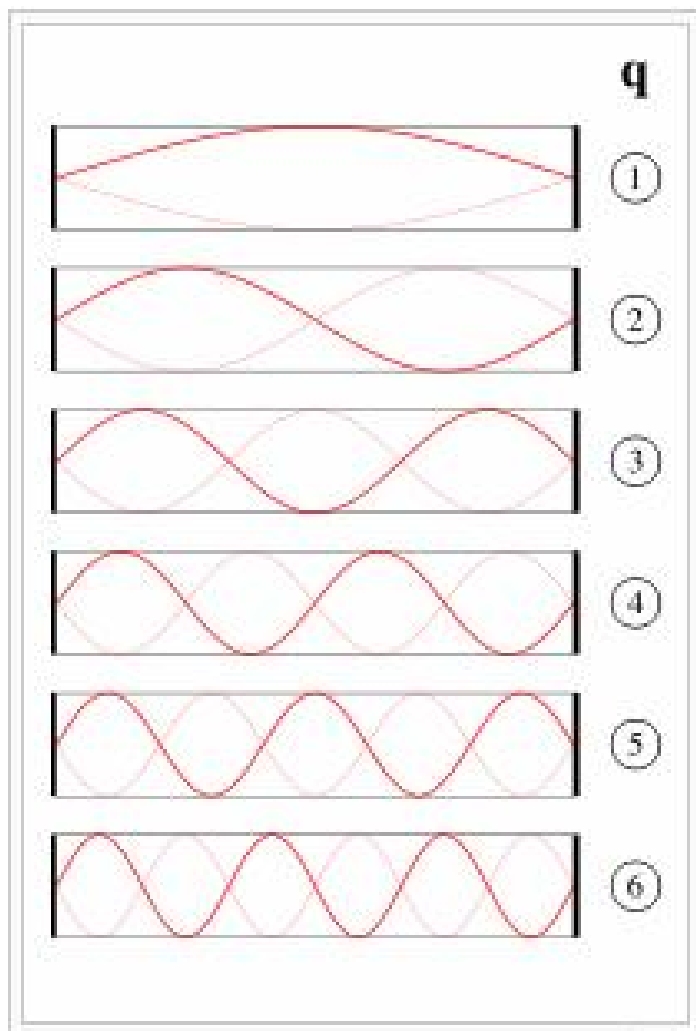
Условия за получаване на лазерна генерация



$$I/I_0 = R_1 R_2 \exp(2g_{\text{threshold}} l) \exp(-2\alpha l) = 1.$$

$$g_{\text{threshold}} = \alpha_0 - \frac{1}{2l} \ln(R_1 R_2).$$

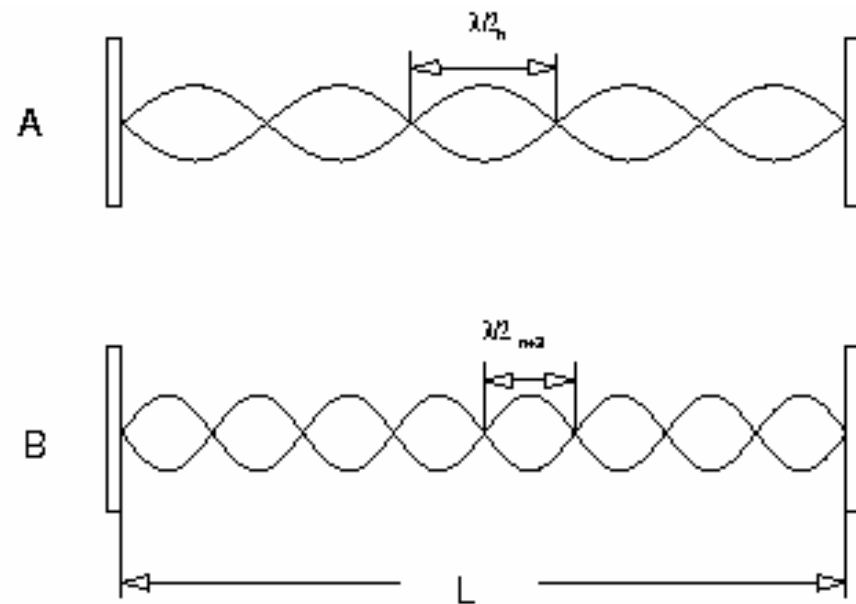
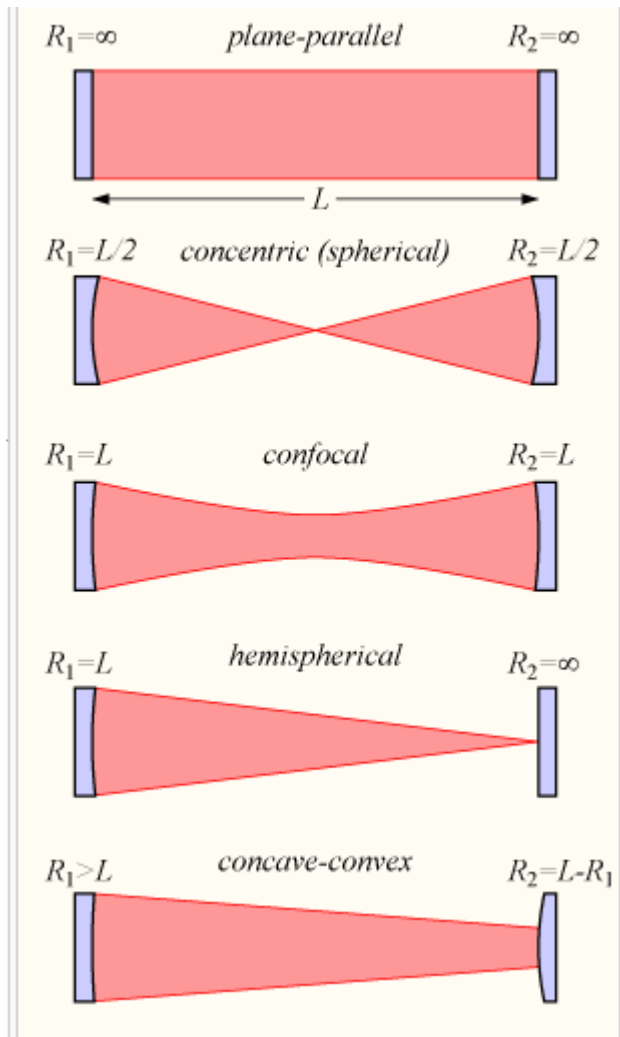
**В оптичните резонатори се установяват надлъжни стоящи
вълни.**



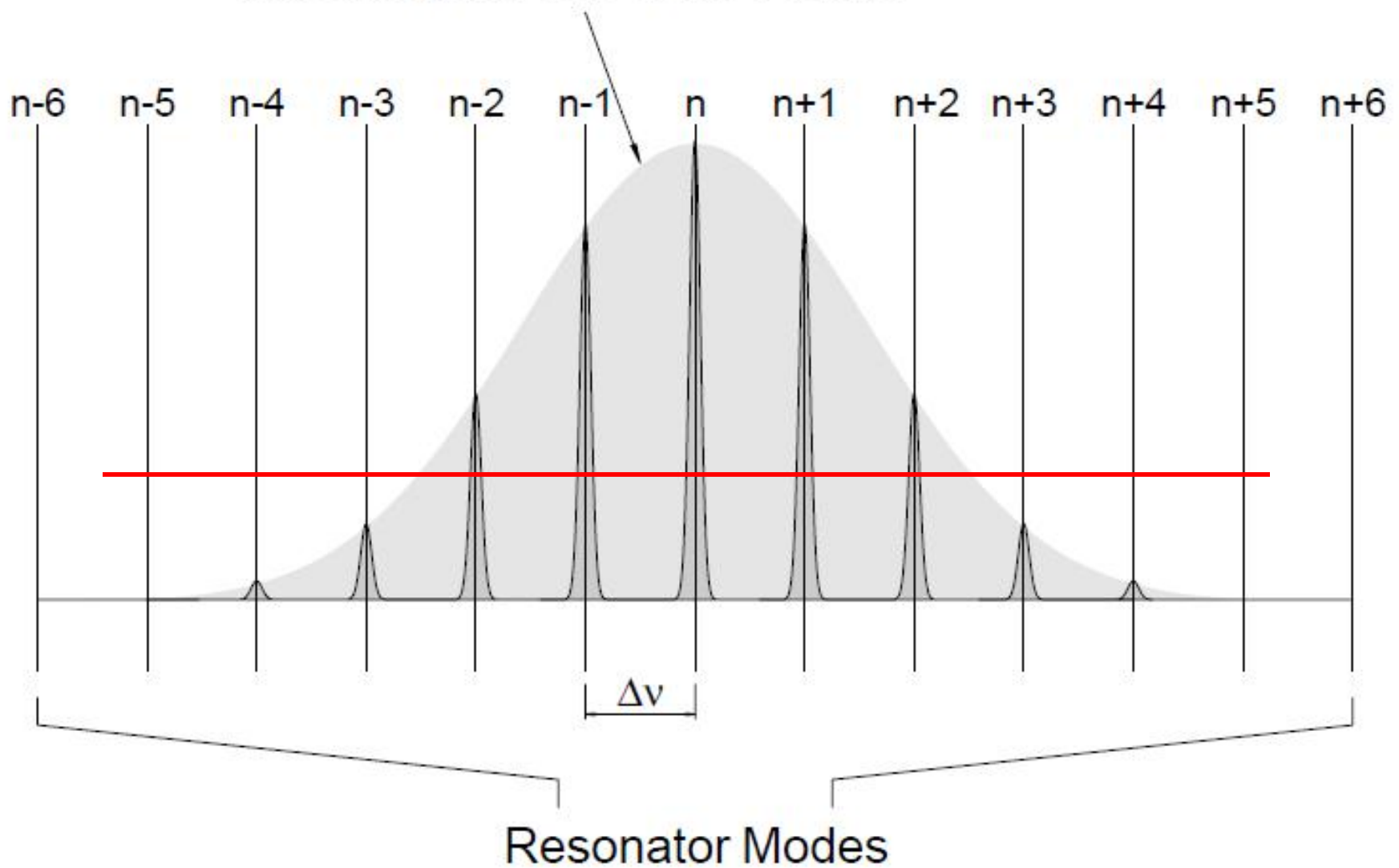
$$L = q \frac{\lambda}{2}$$

$$\Delta\nu = \frac{c}{2nL}$$

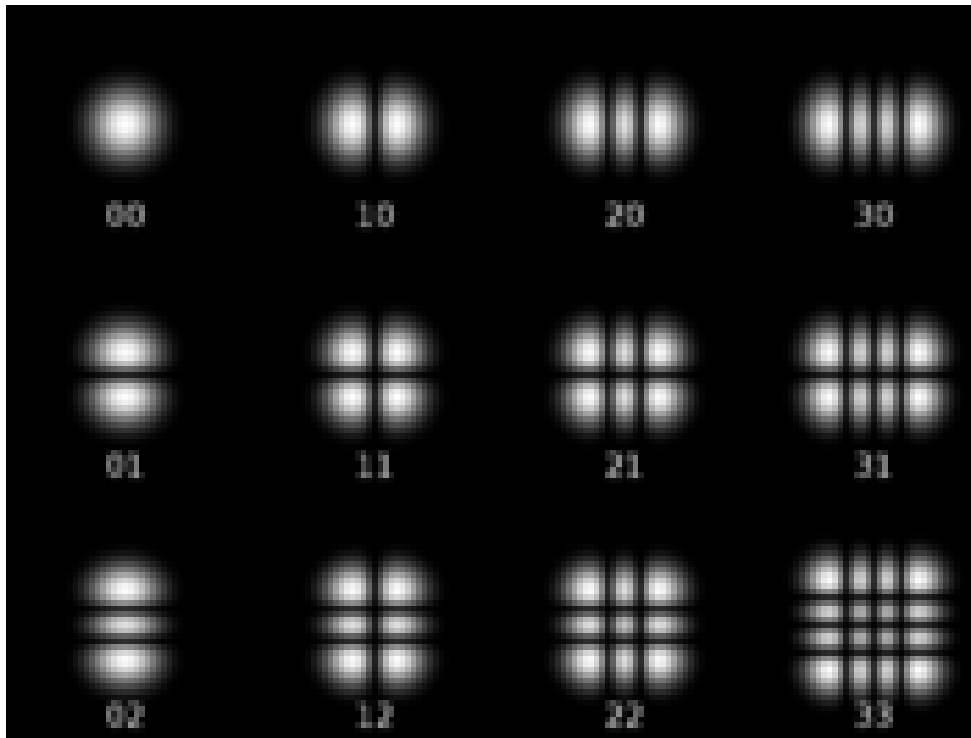
Типични лазерни резонатори



Inhomogeneous Gain Profile

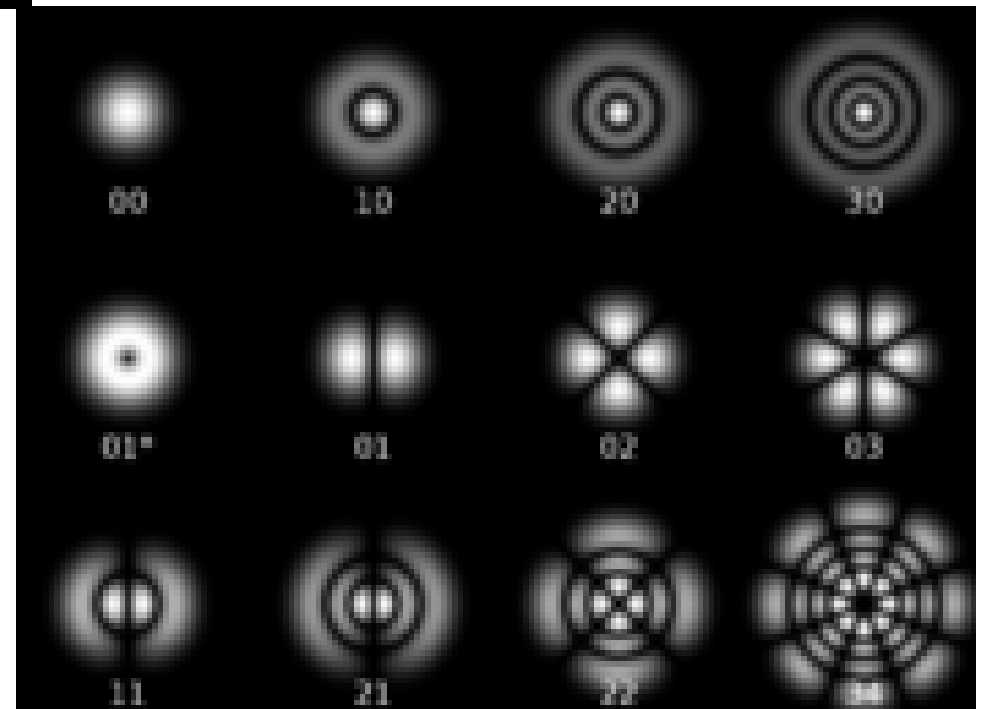


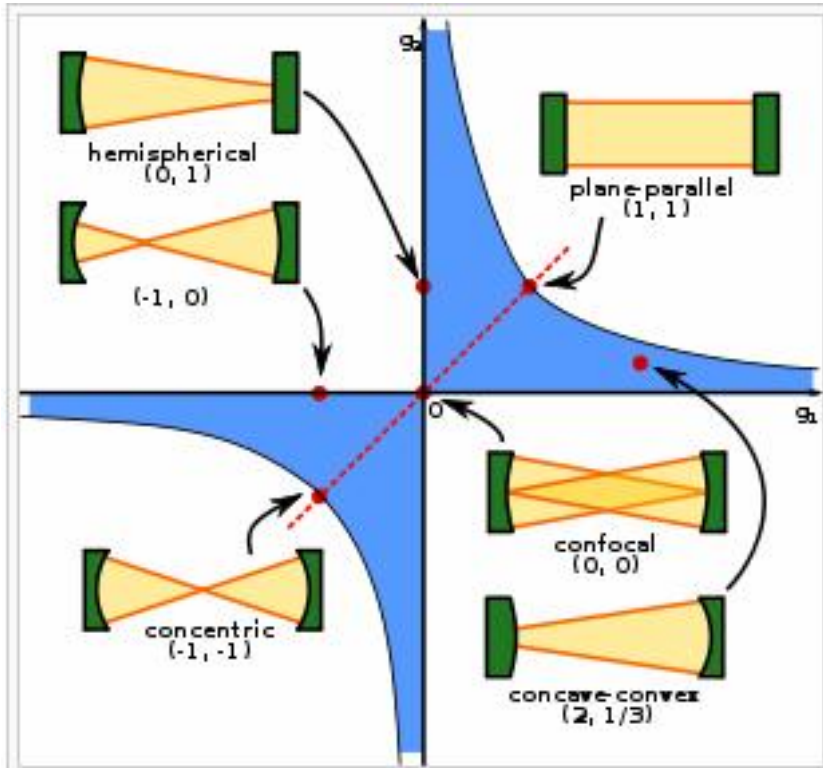
Условия за възникване на лазерна генерация



Напречни модове в резонатори с цилиндрична симетрия

Напречни модове в резонатори с правоъгълни огледала



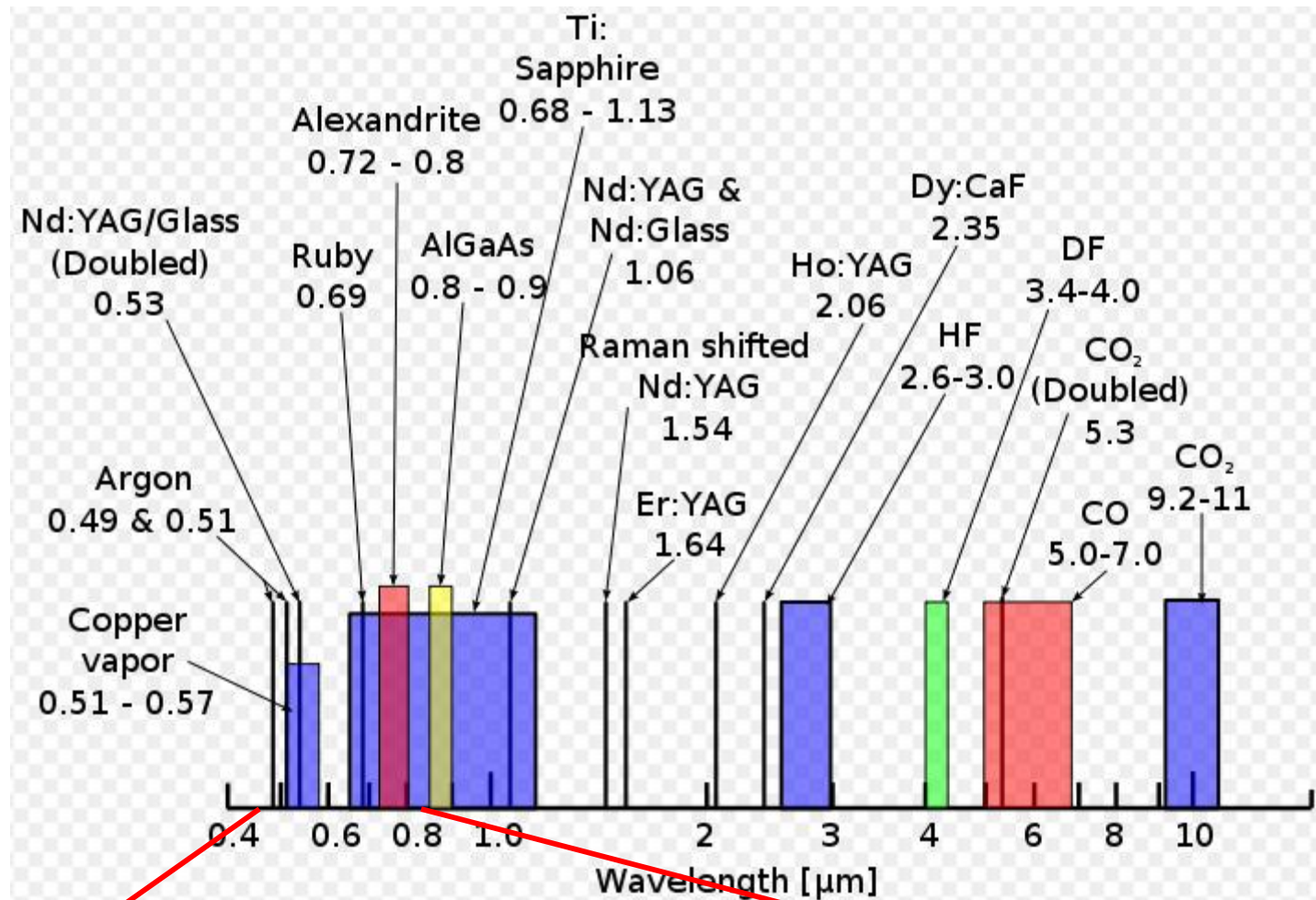


$$0 \leq \left(1 - \frac{L}{R_1}\right) \left(1 - \frac{L}{R_2}\right) \leq 1.$$

$$g_1 = 1 - \frac{L}{R_1}, \quad g_2 = 1 - \frac{L}{R_2}.$$

Условие за стабилност на лазерен резонатор.

Дължини на вълните на излъчване на различни лазери



Отражатели

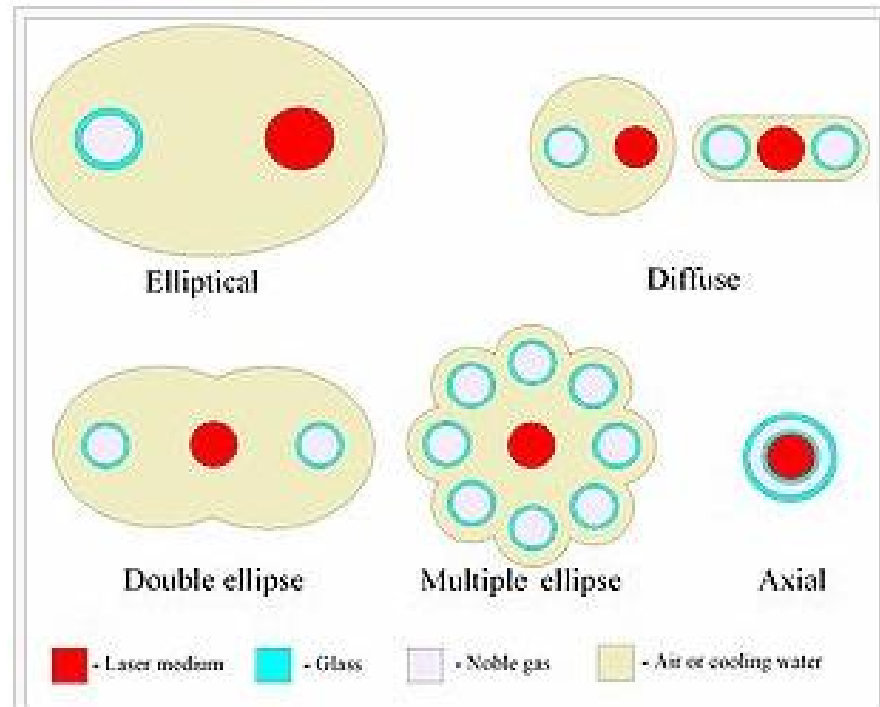
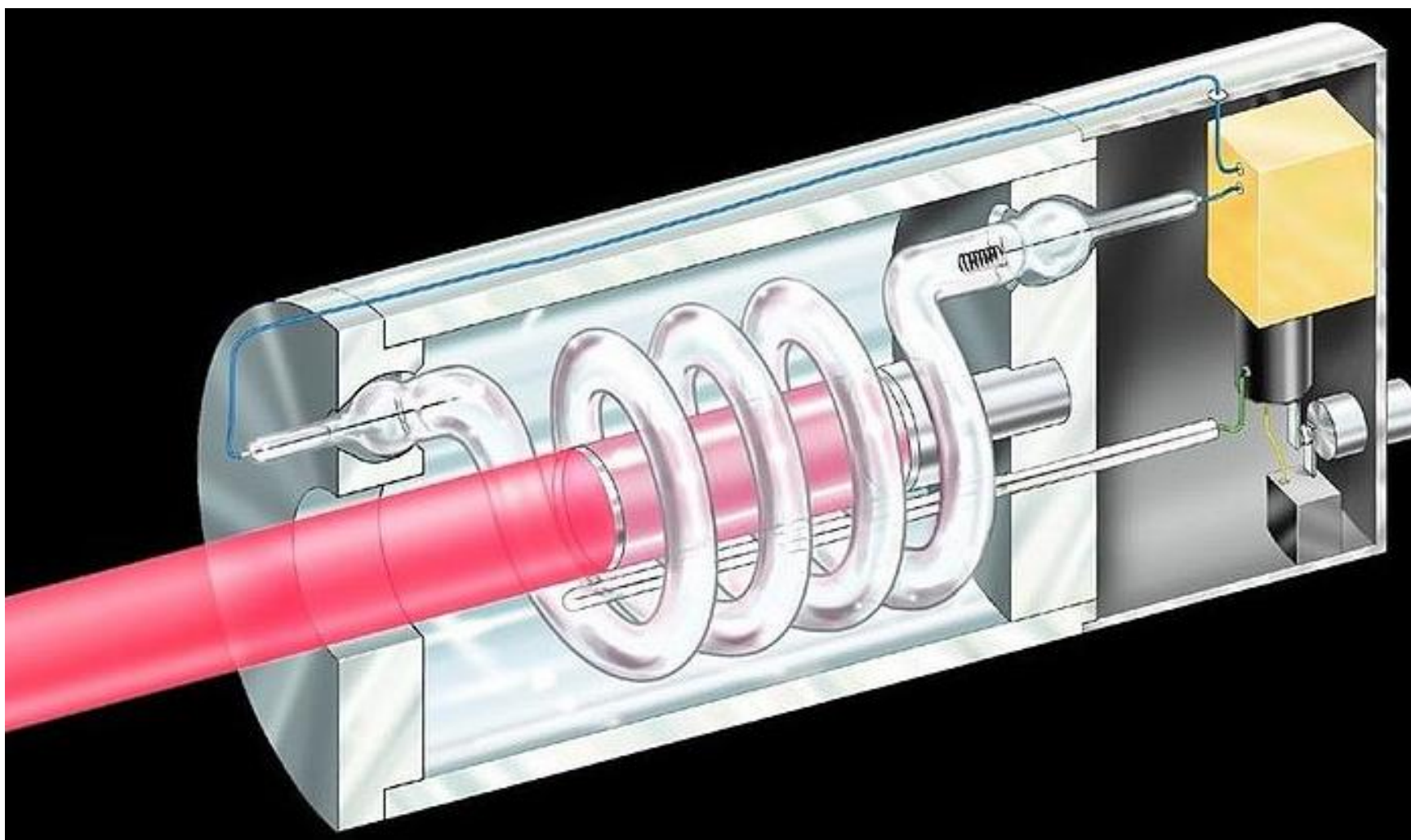
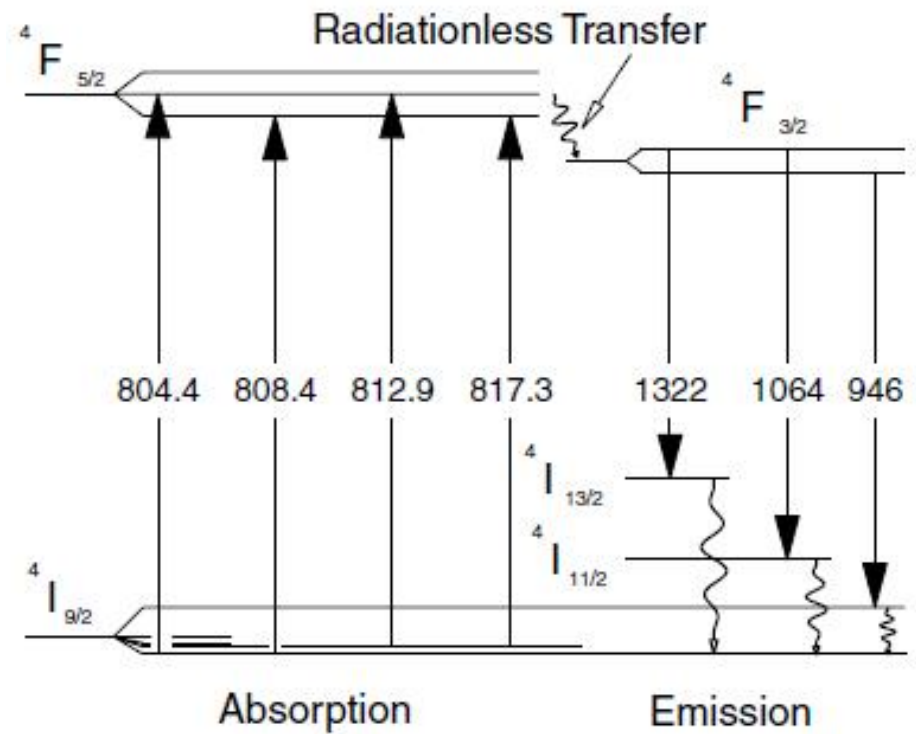
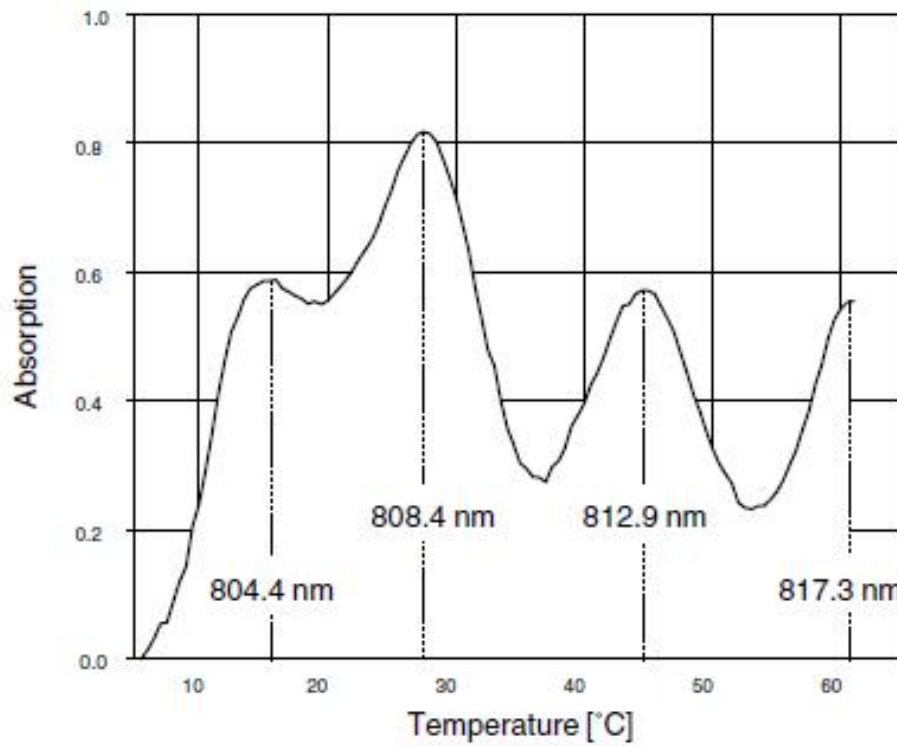


Схема на първия рубинов лазер



Поглъщане и излъчване на Nd³⁺



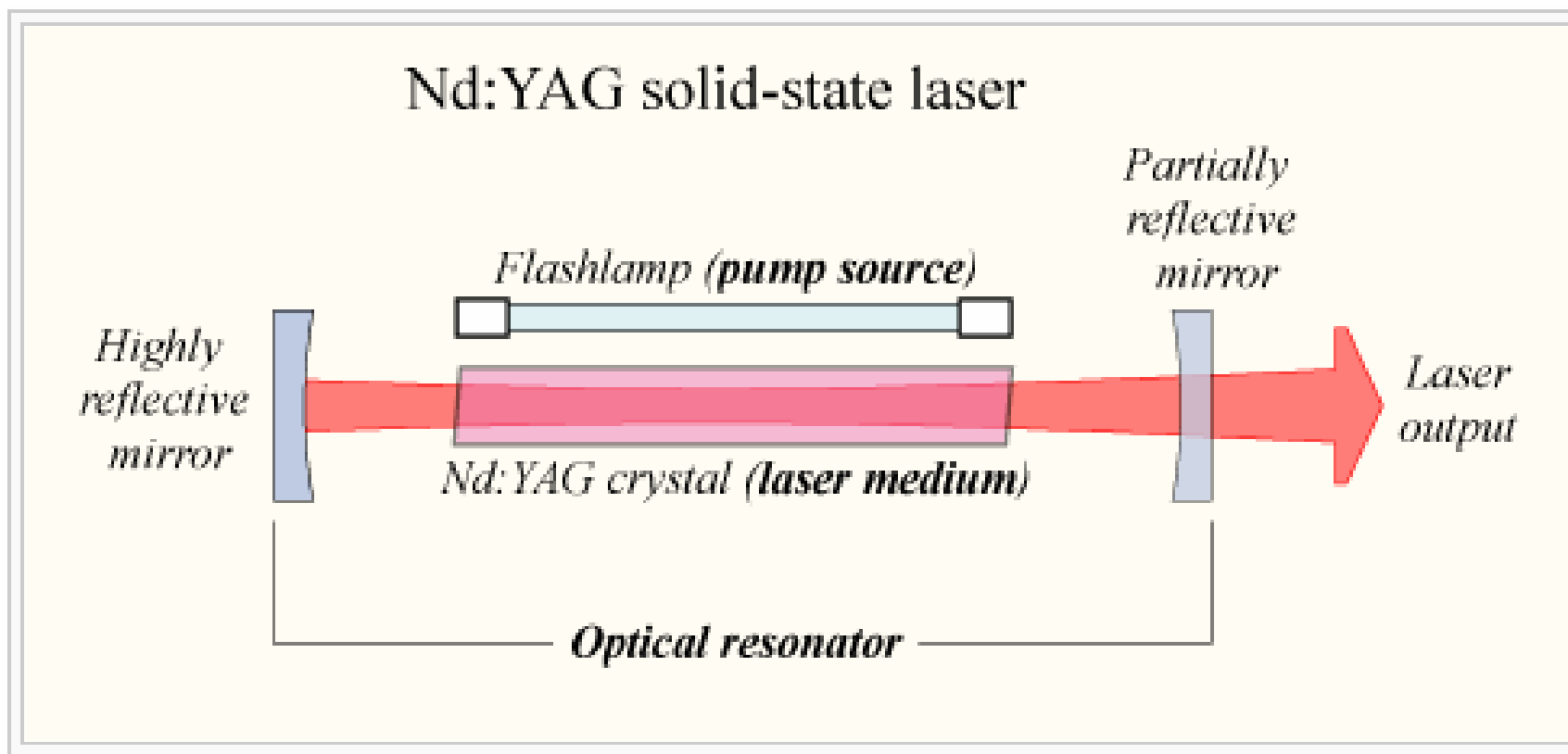
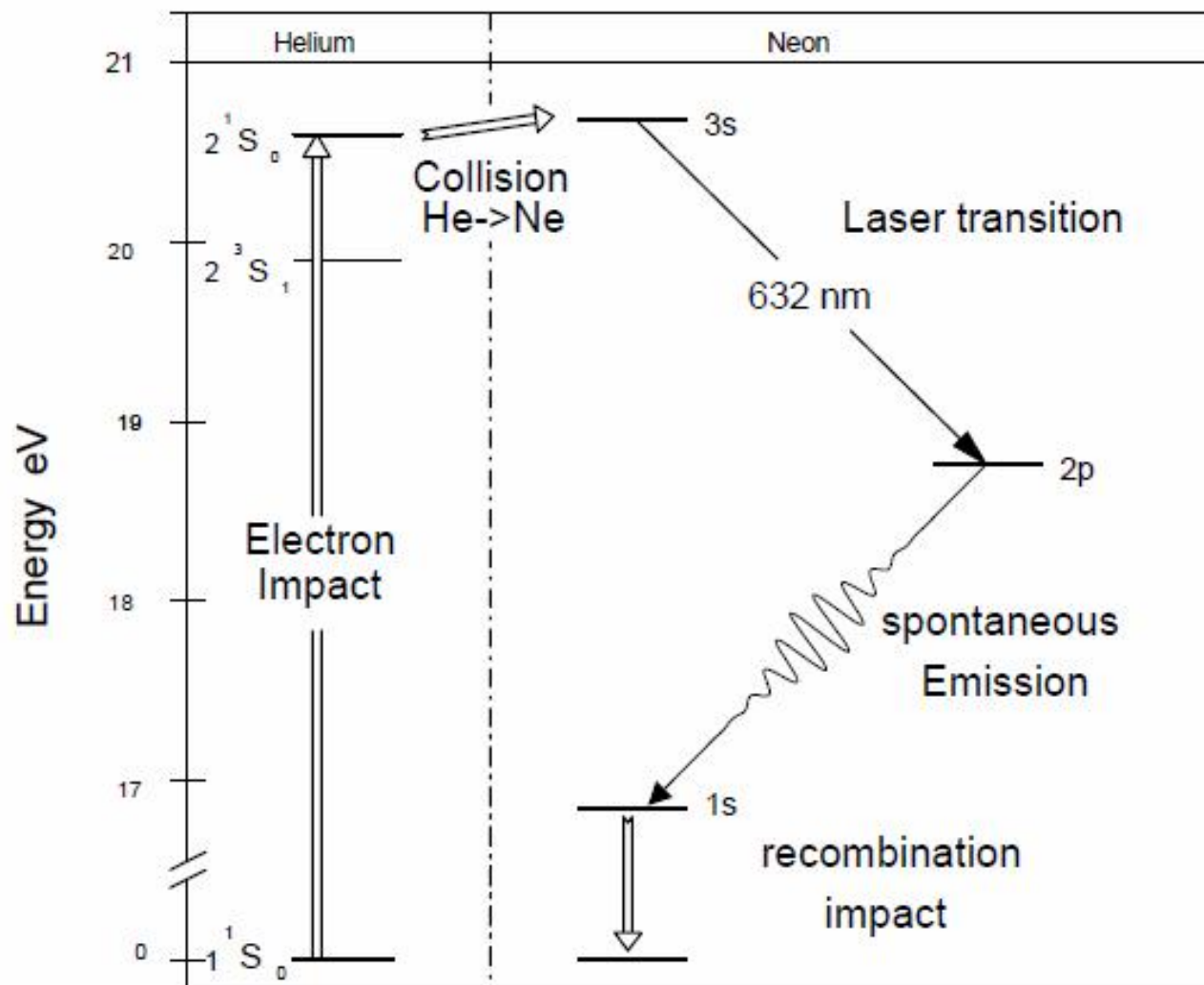
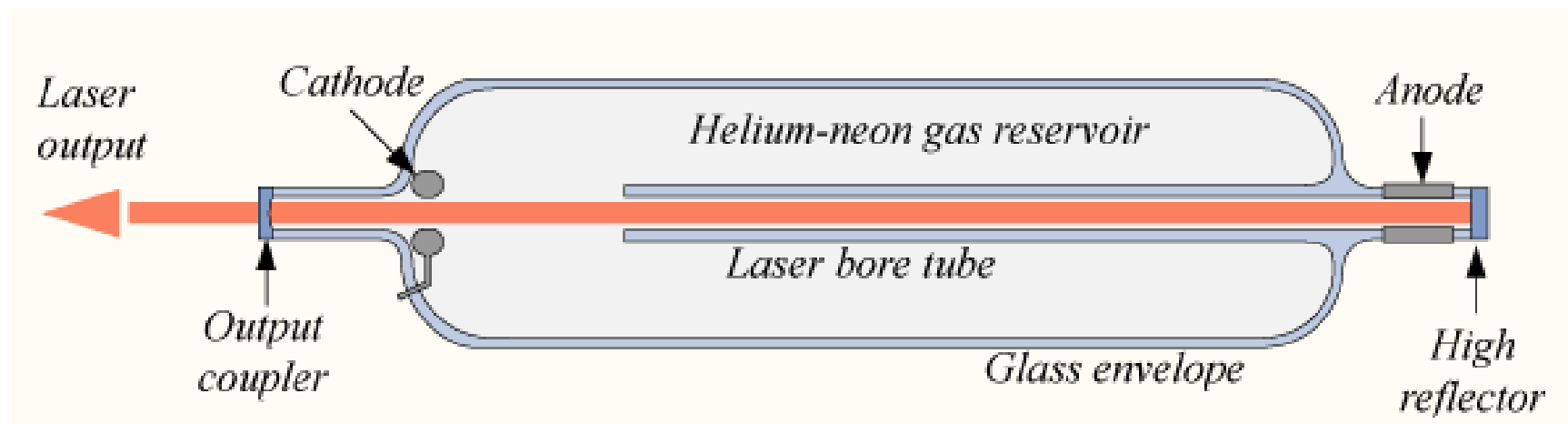


Схема на твърдотелен (неодимов) лазер.

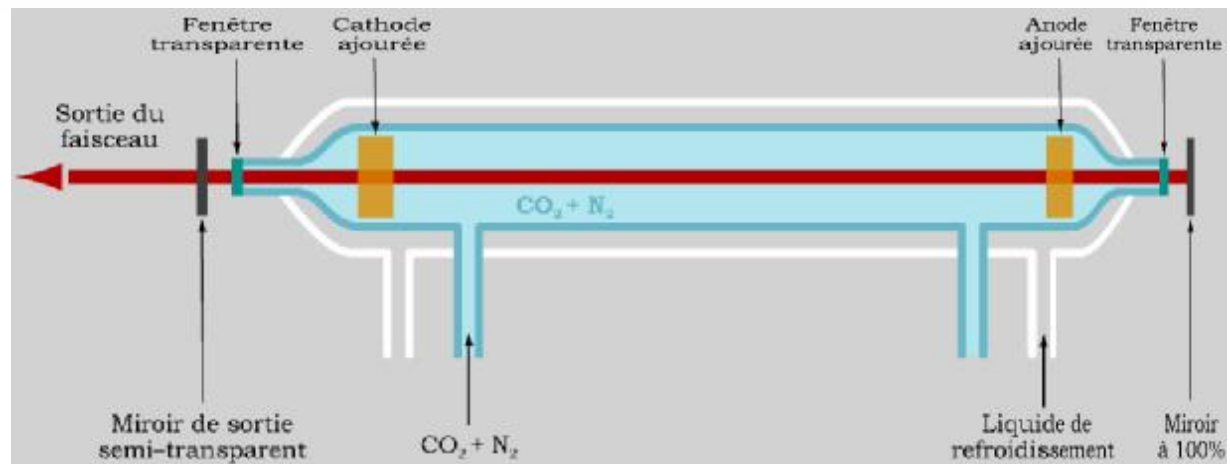
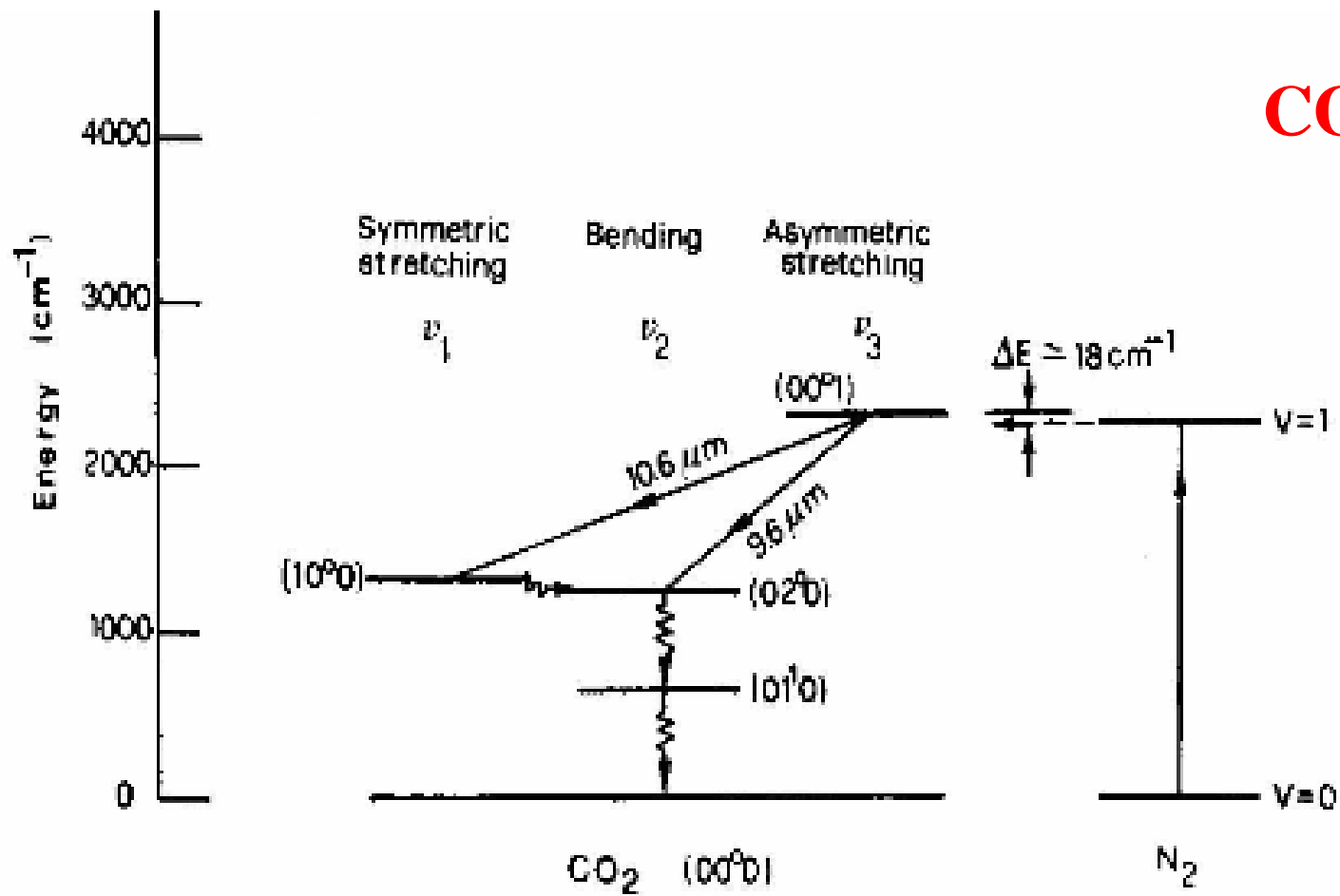


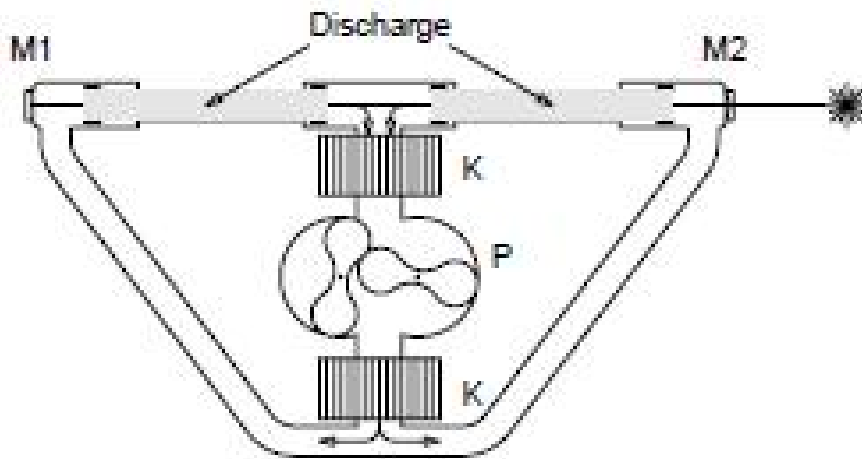
Принцип на действието на хелий-неонов лазер



Конструкция на хелий-неонов лазер

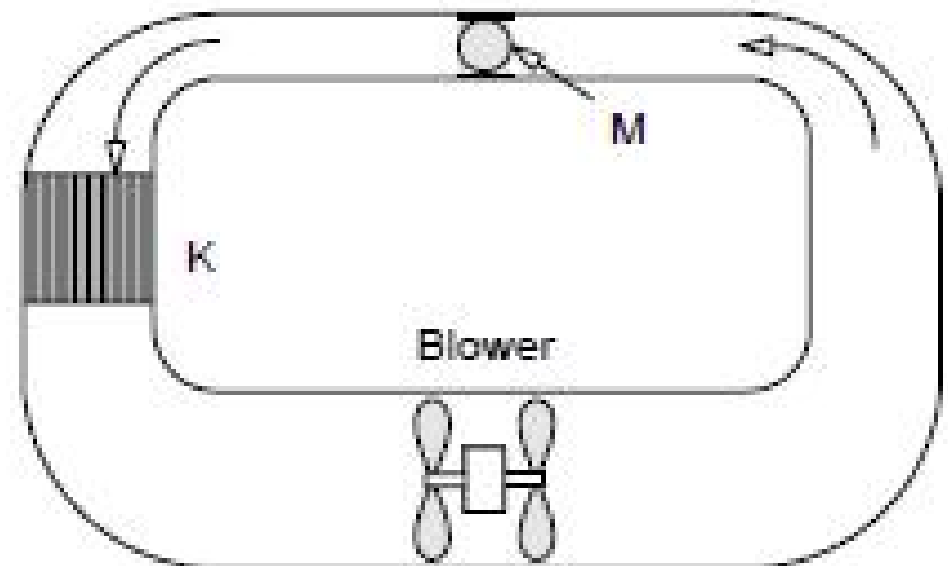
CO₂ -лазер





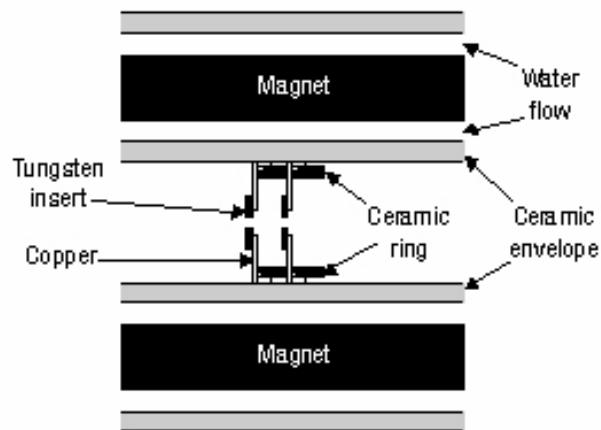
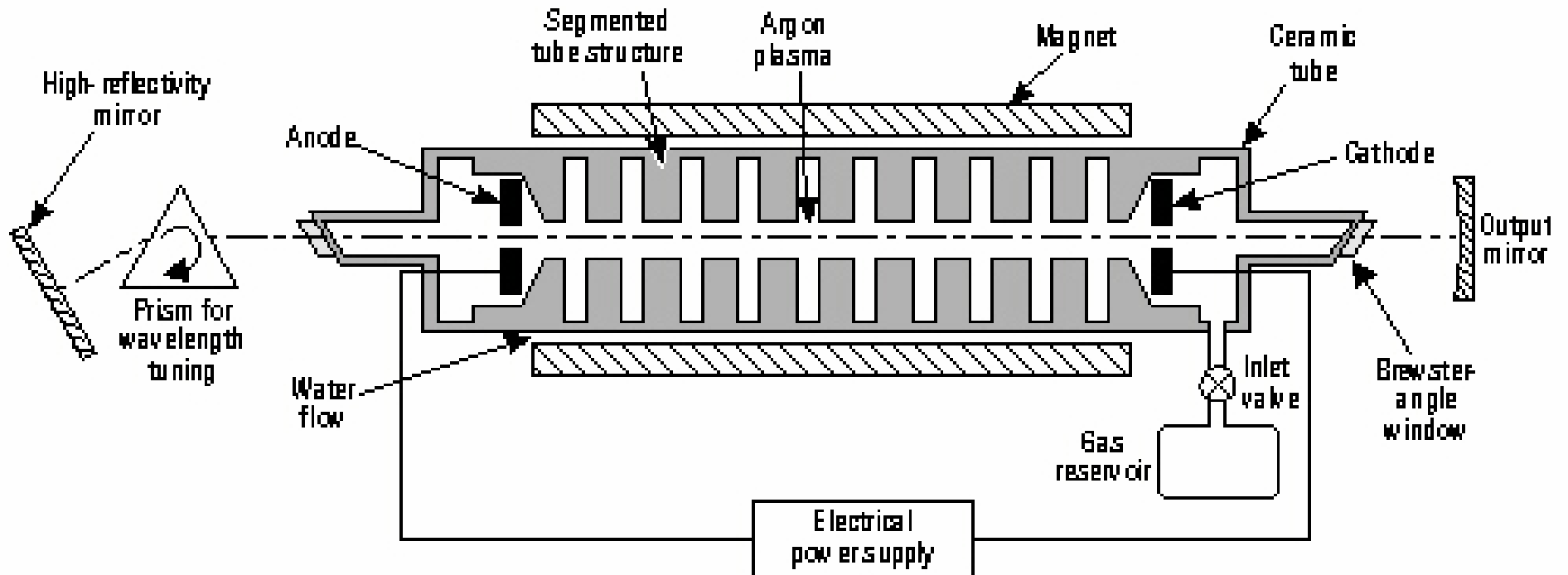
Transversal discharge

**CO₂-лазер с бърз надлъжен
проток на газа**

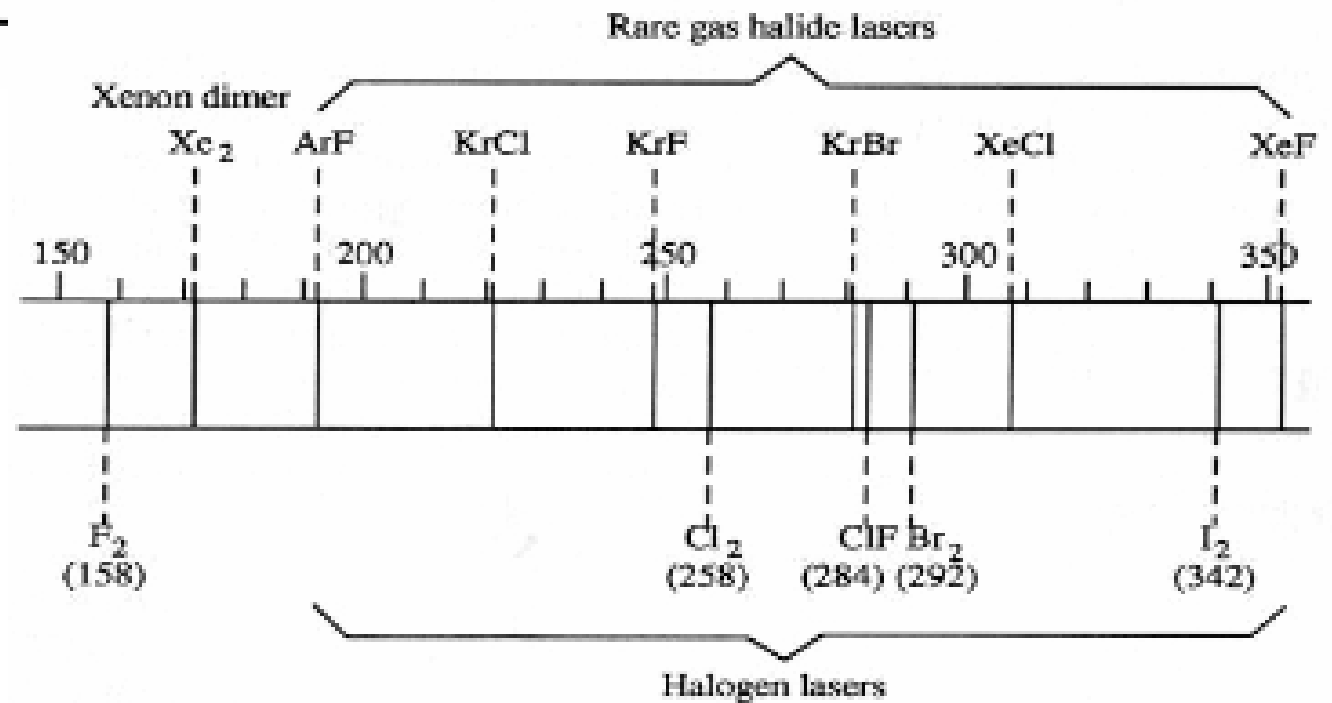
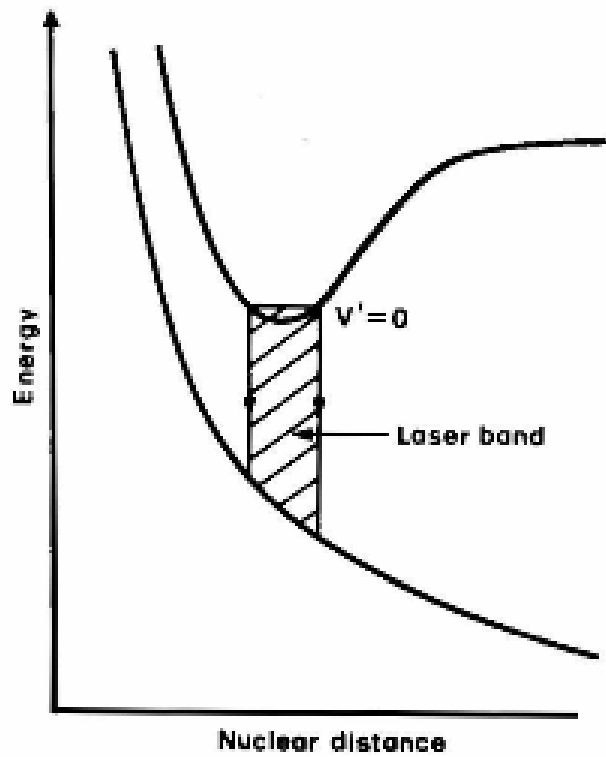


TEA-CO₂-лазер

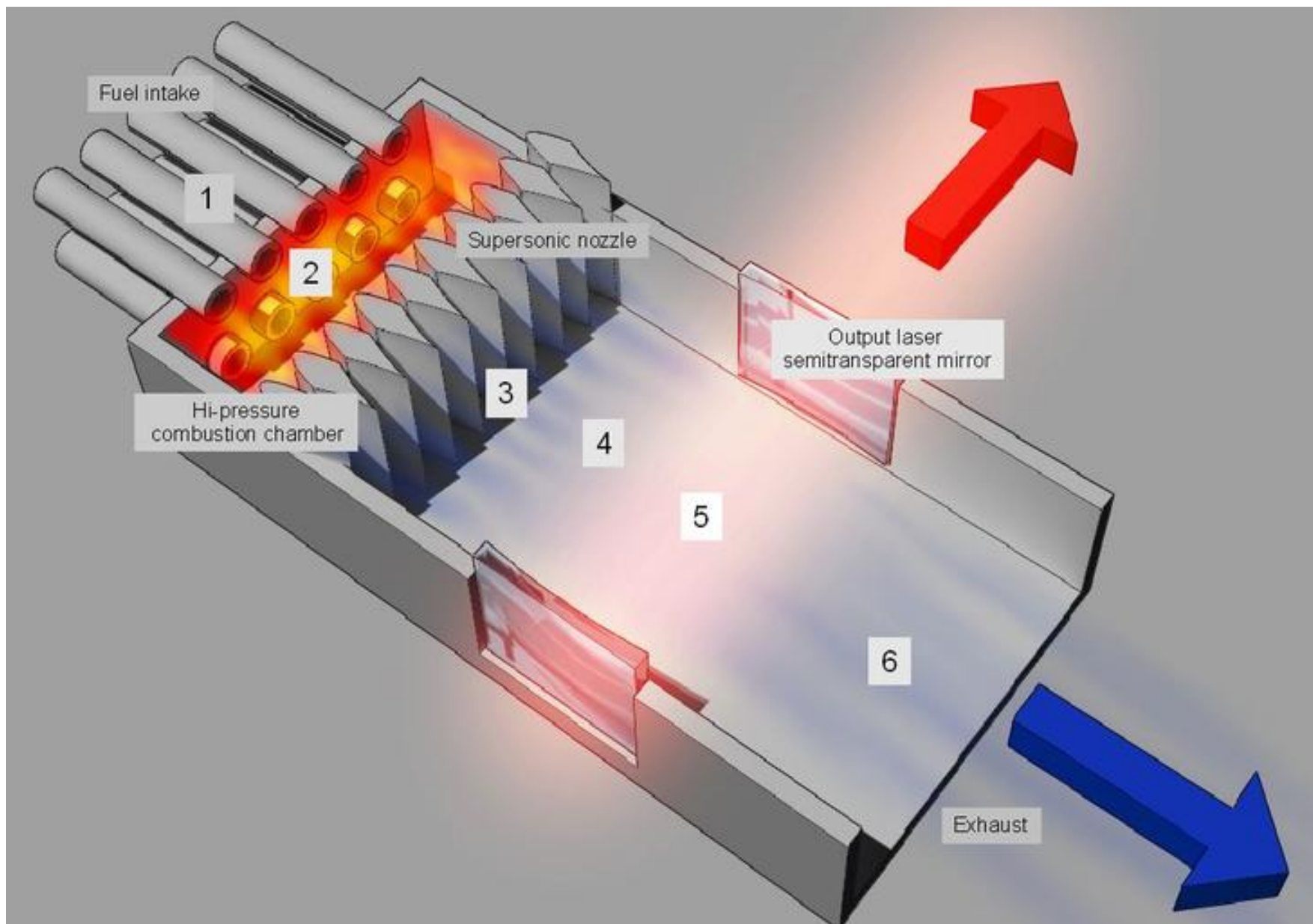
Аргонов йонен лазер



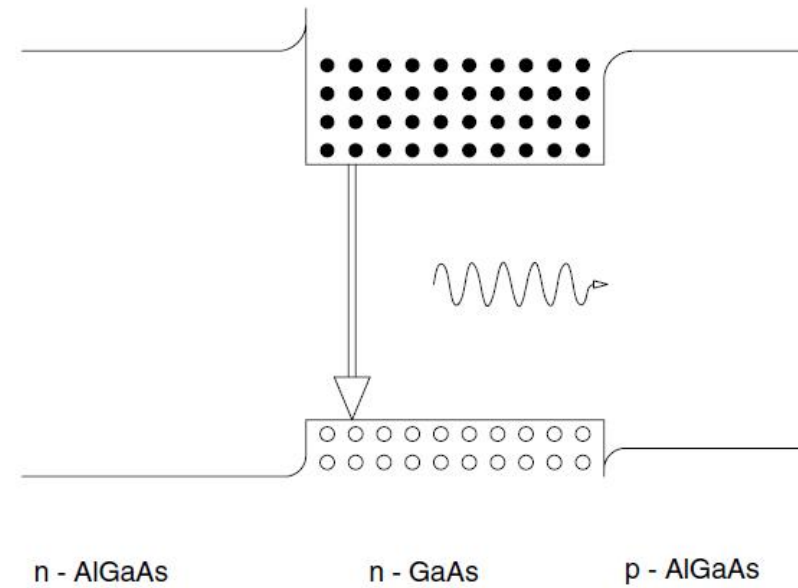
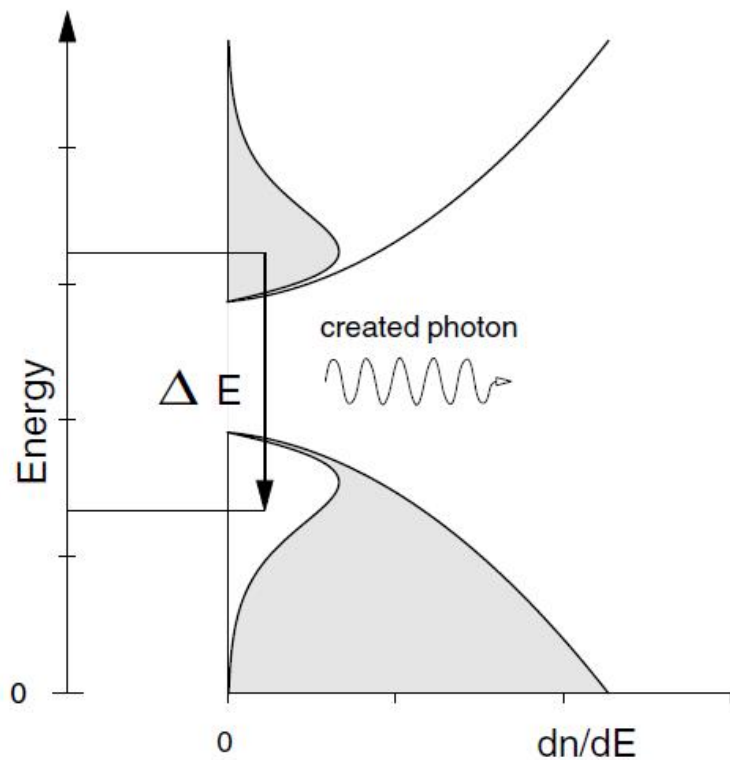
Ексимерни лазери



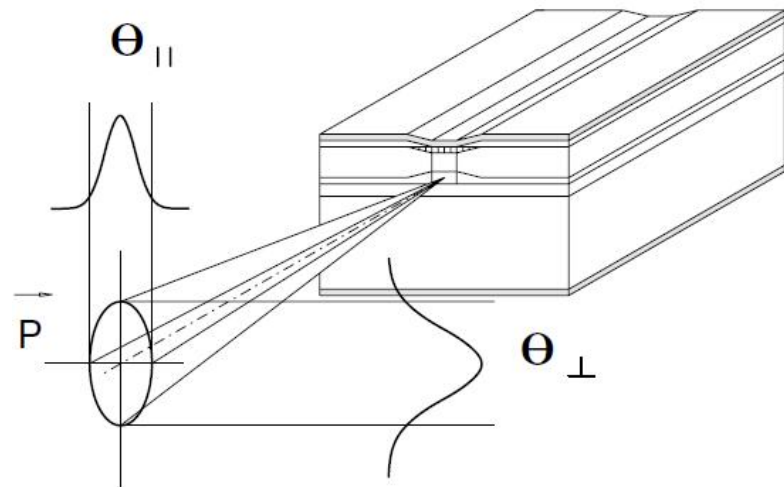
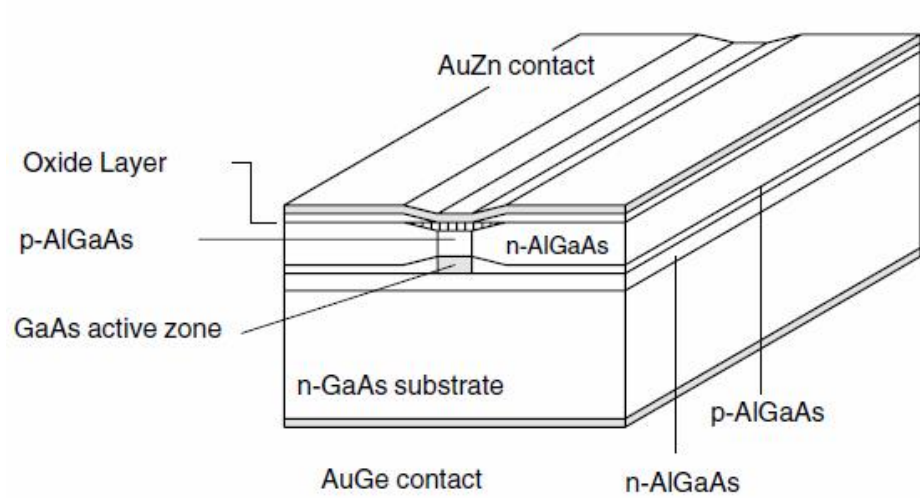
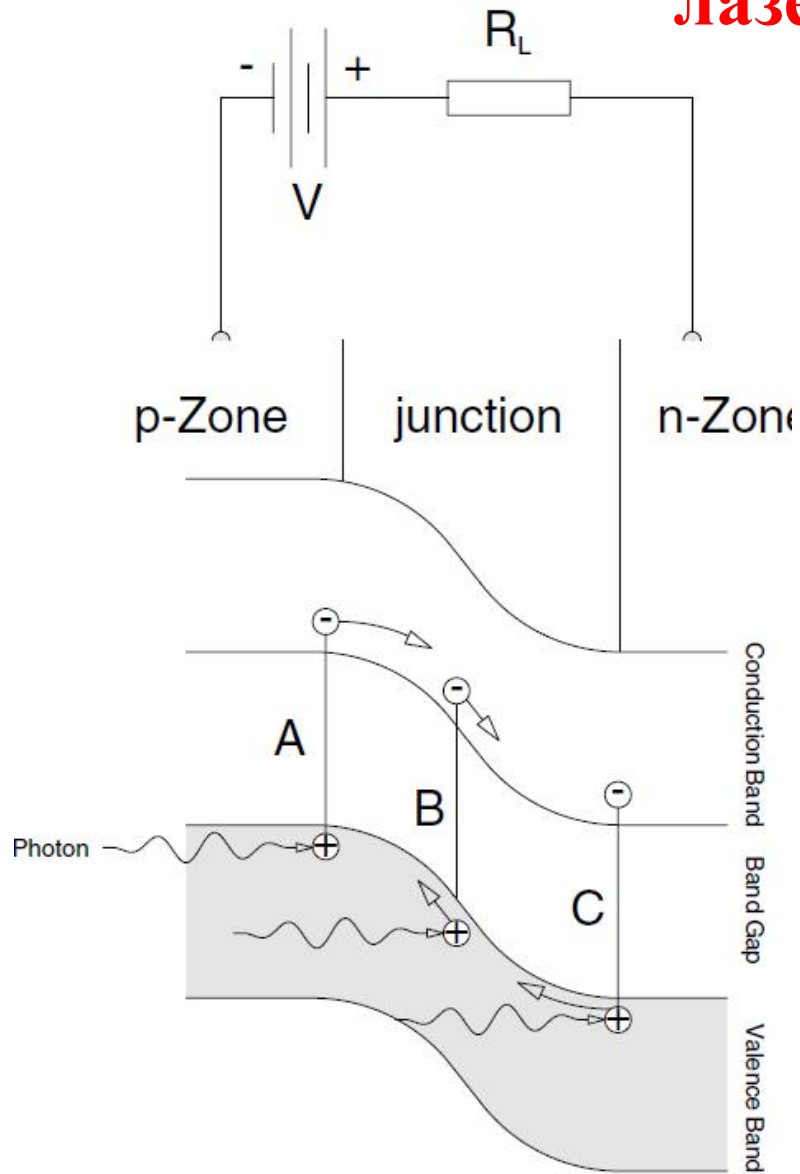
Газодинамични лазери (**HF**(2700-2900 nm) ; **DF** (3800 nm))



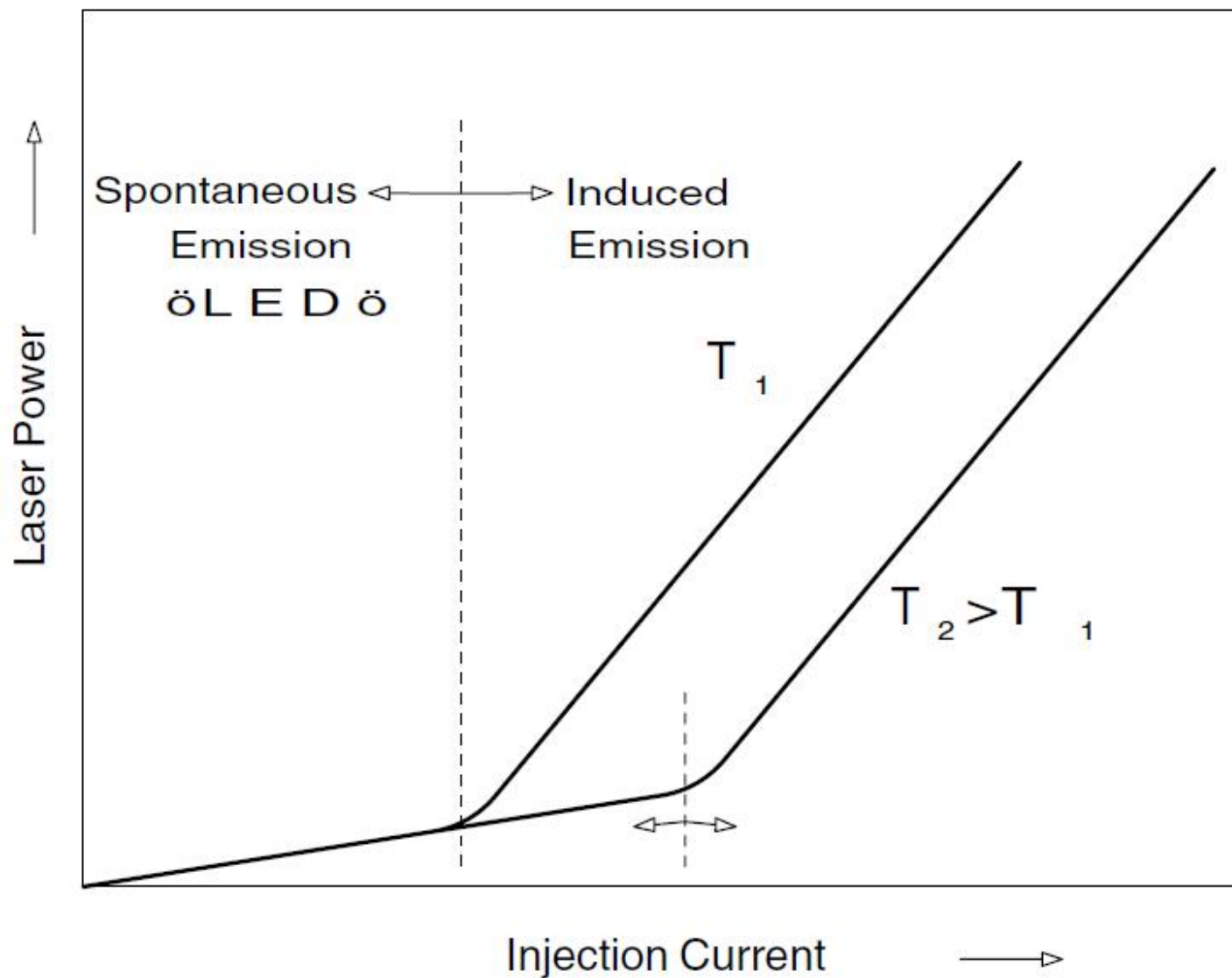
Полупроводникови лазери (лазерни диоди)



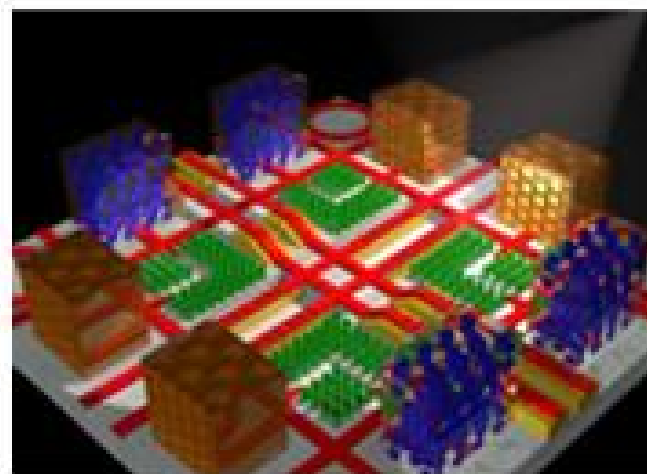
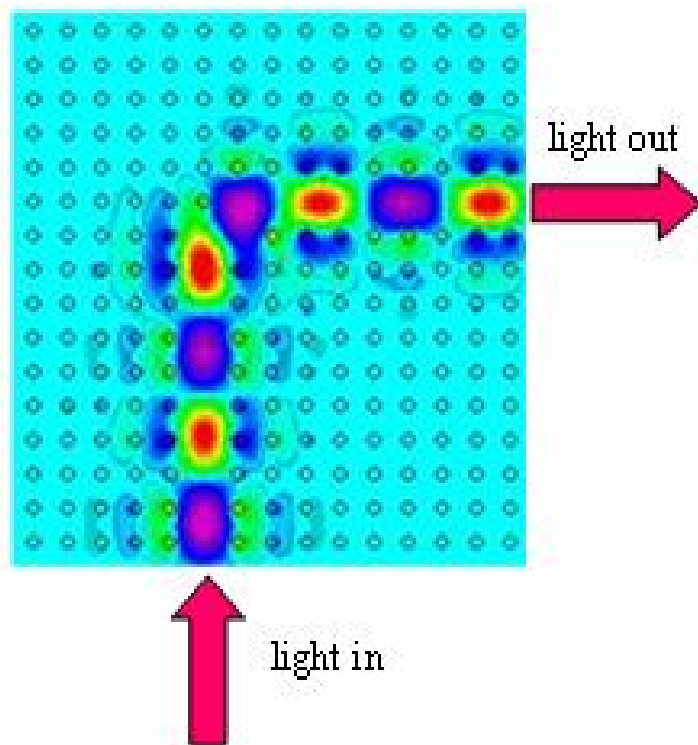
Принцип на действие и хетероструктурни лазерни диоди



Всеки полупроводников лазер може да работи като светодиод, но обратното не е вярно.

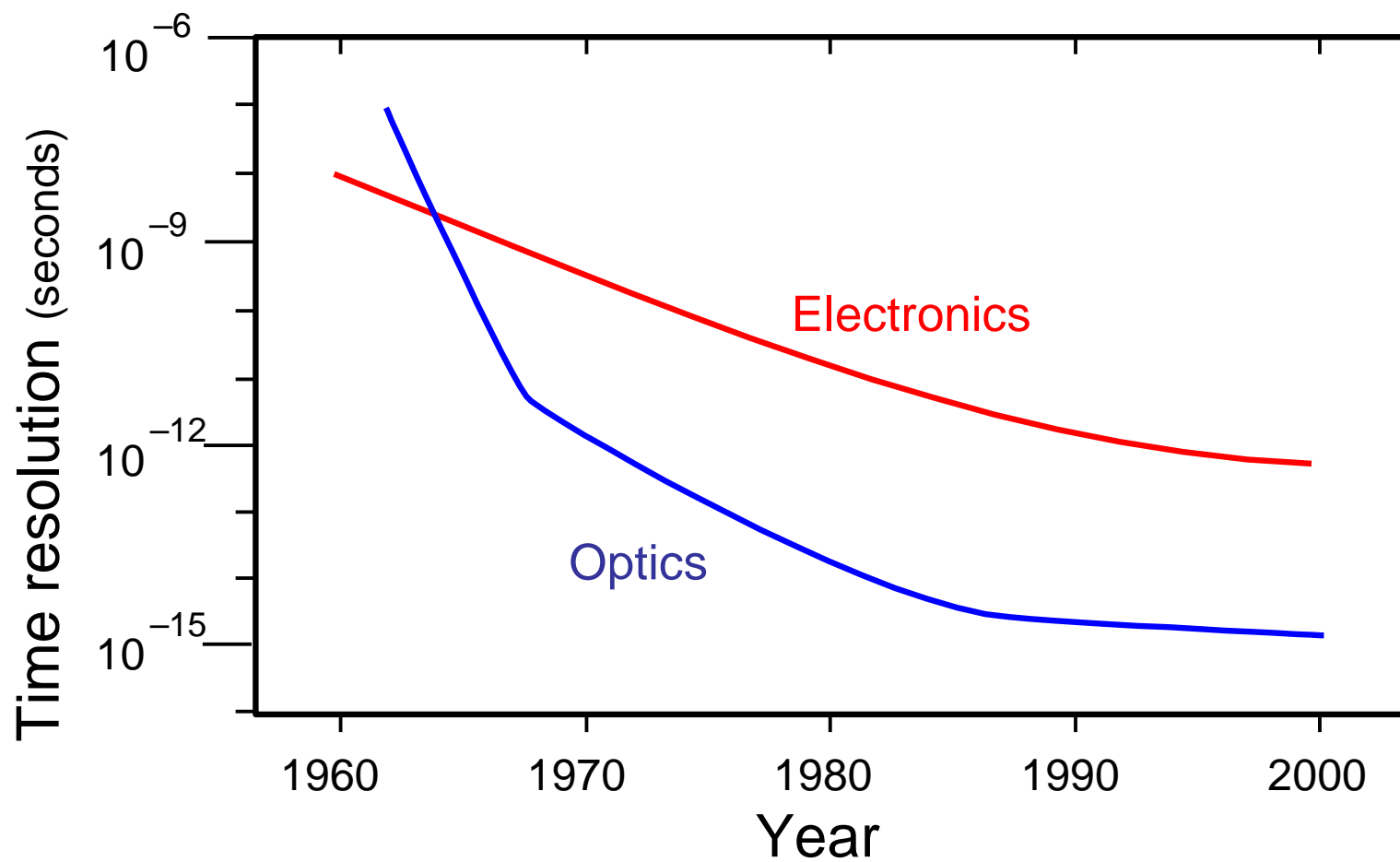


През 21 век фотониката ще измести в много области електрониката. Късите лазерни импулси са необходими за предаване на информация с висока плътност.



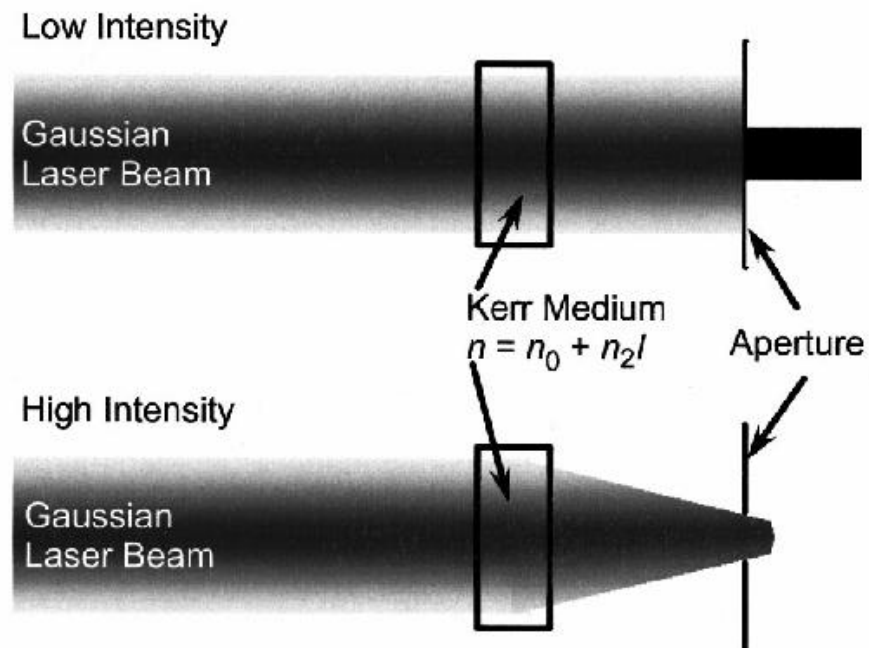
фотонни мрежи

Какво означава “бързо” в оптиката и в електрониката?



Лазери, излъчващи фемтосекундни импулси

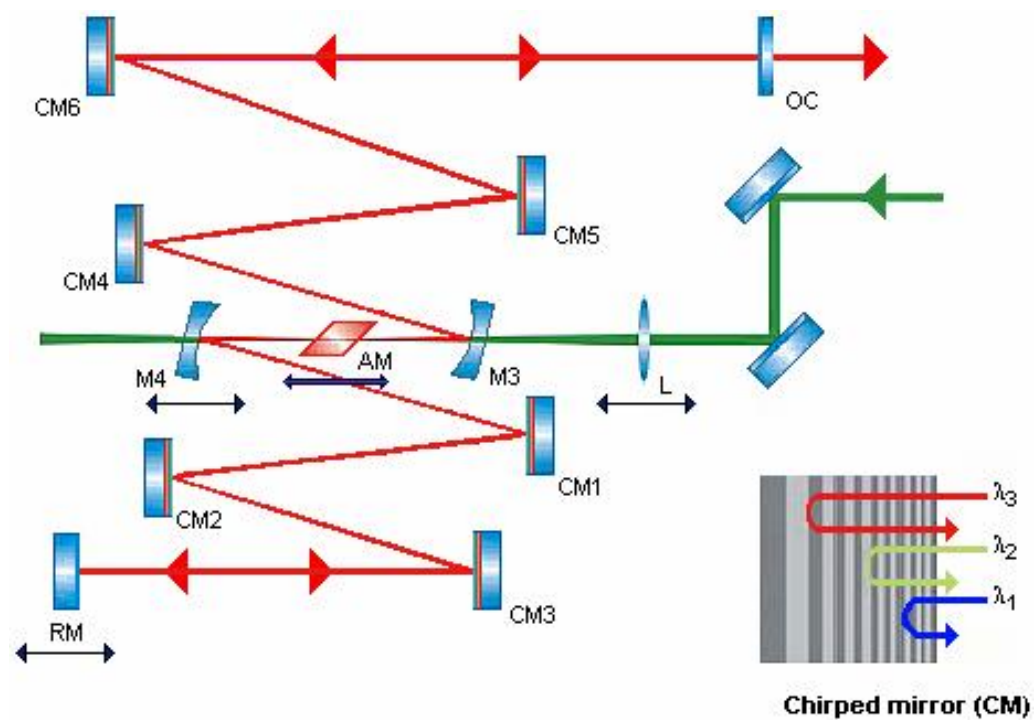
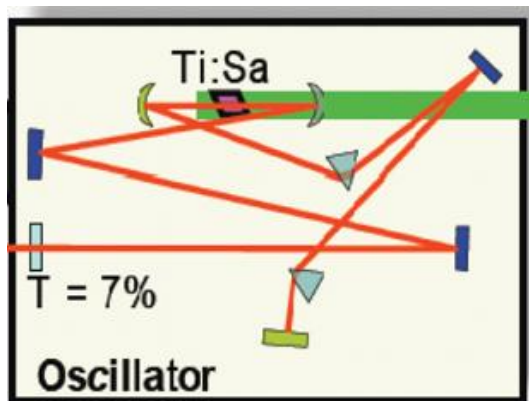
Kerr-lens:



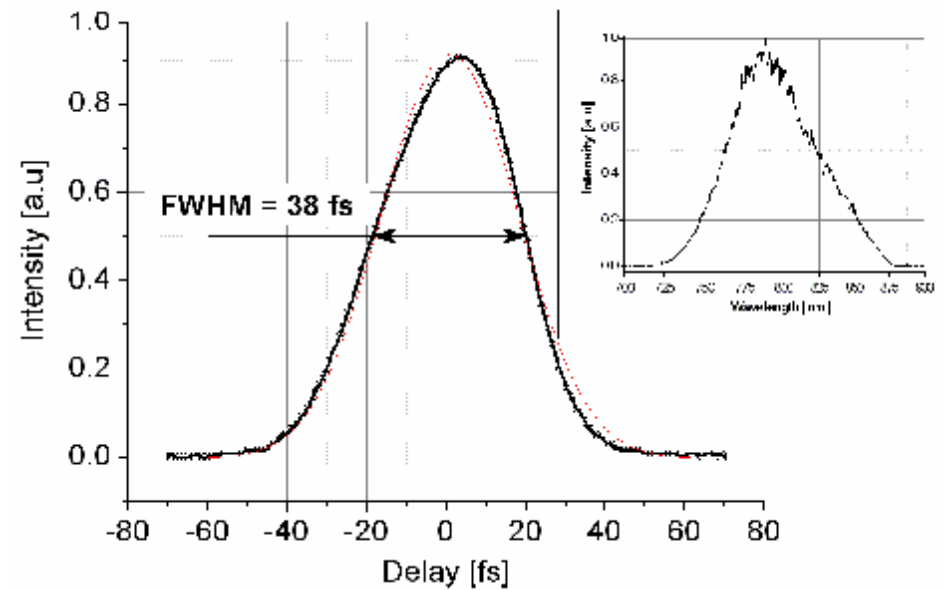
Dispersion control :

$$T(\omega) = \frac{\partial \phi}{\partial \omega} = \phi'(\omega_0) + \phi''(\omega_0) \Delta\omega + \frac{1}{2} \phi'''(\omega_0) \Delta\omega^2 + \frac{1}{6} \phi''''(\omega_0) \Delta\omega^3 + \dots,$$

Фемтосекунден генератор: Симетрична или асиметрична компенсация на дисперсията?



Фемтосекунден генератор в катедра Квантова електроника



- $\lambda_c = 790\text{nm}$
- $\Delta t = 28\text{fs}$ (Gaussian shaped pulse)
- $f_{\text{rep}} = 83\text{MHz}$
- $W = 4\text{nJ}$

