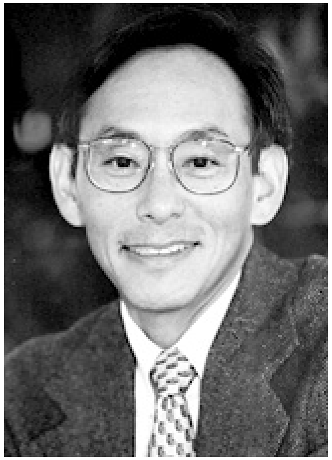
The Nobel Prize in Physics 1997

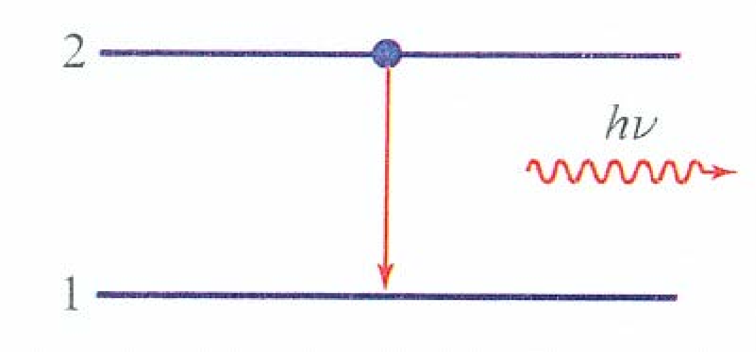
"for development of methods to cool and trap atoms with laser light"



Steven Chu

Claude Cohen-Tannoudji

William D. Phillips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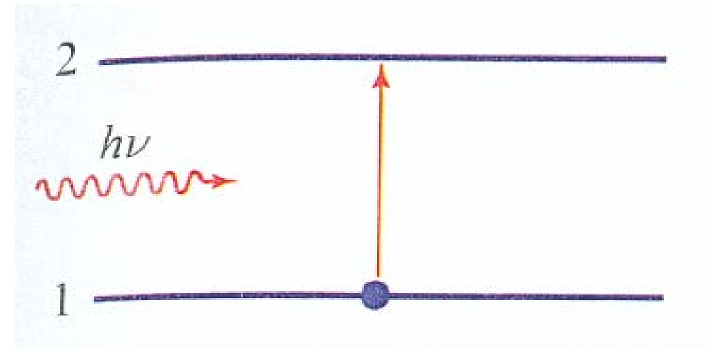
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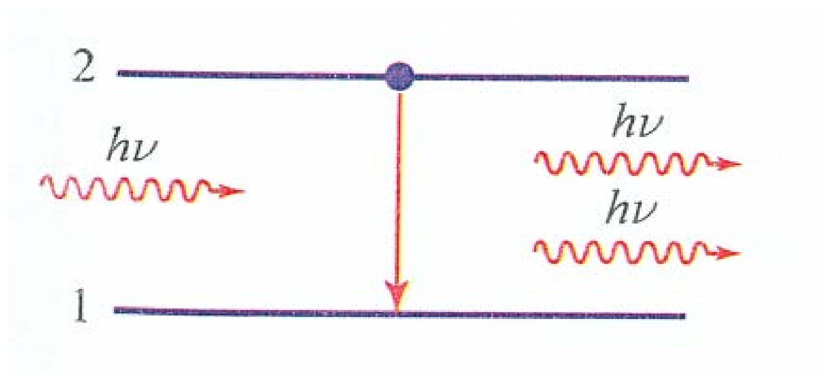
2
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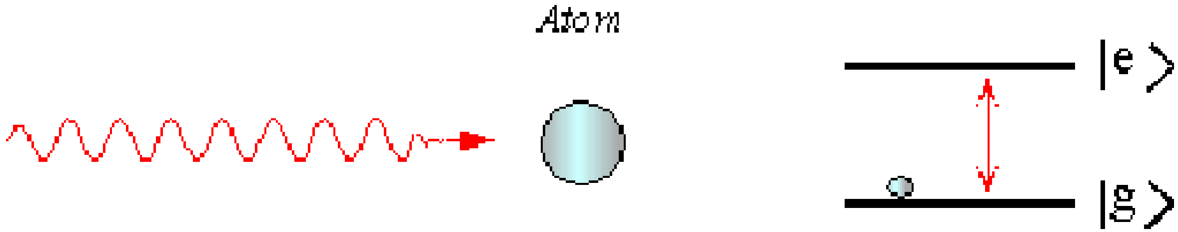
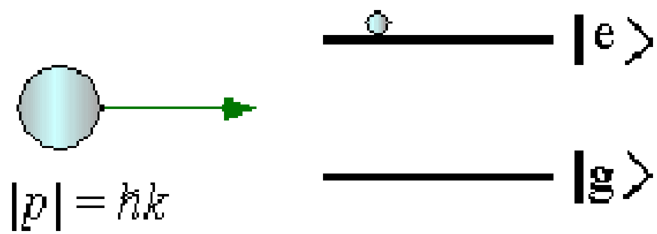
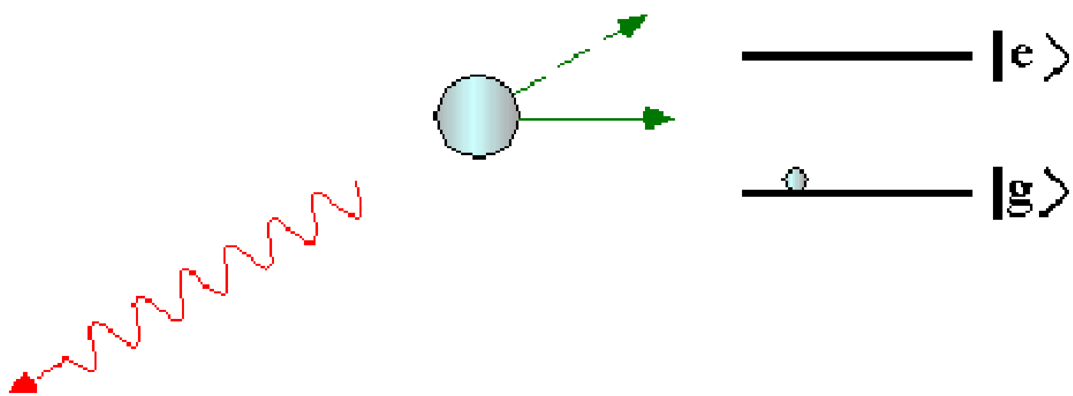


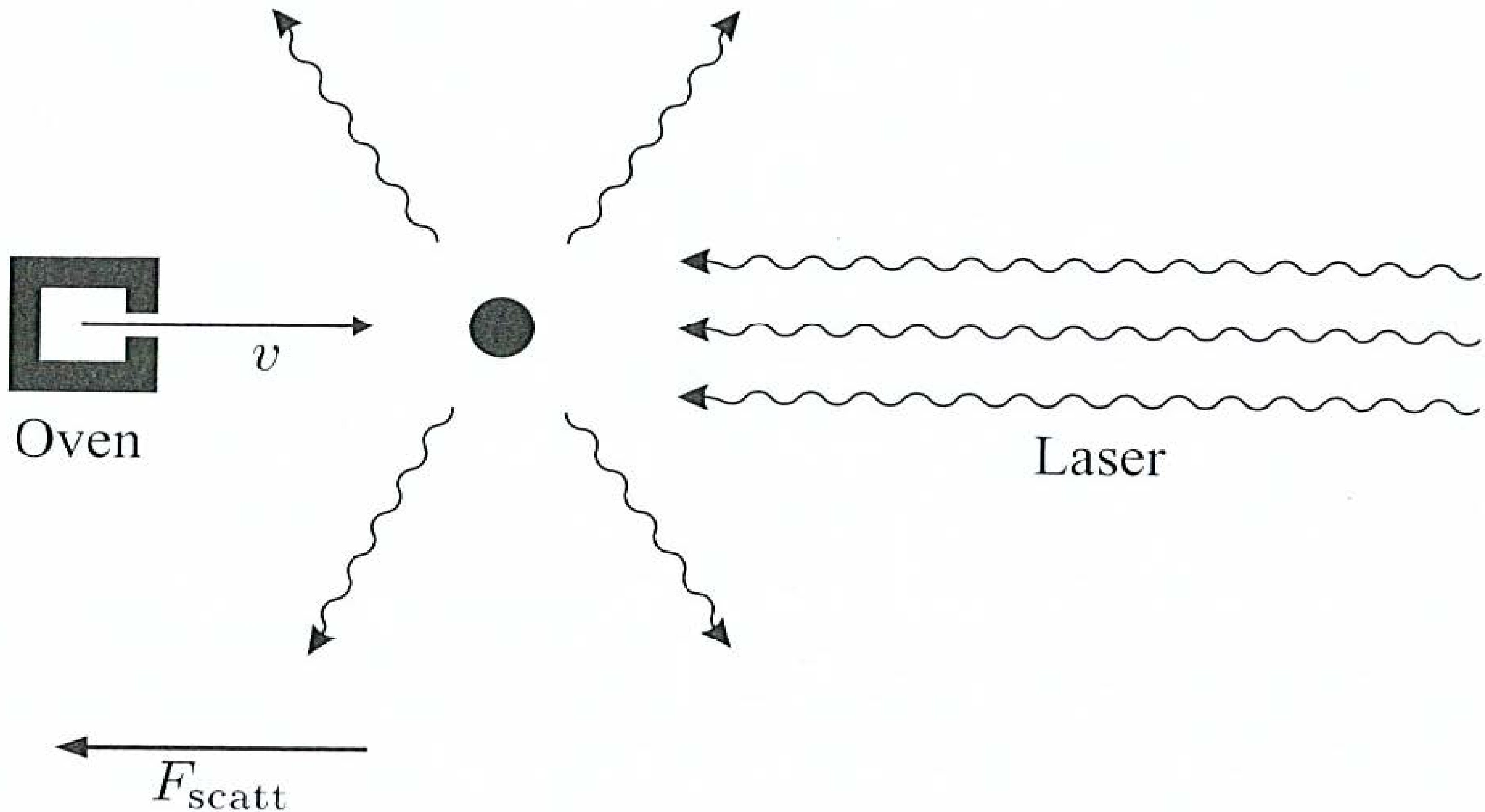
$$\vec{F}_{scatt} = \hbar \vec{k} \Gamma \rho_2$$

$$= \hbar \vec{k} \frac{\Gamma}{2} \frac{I / I_{sat}}{1 + I / I_{sat} + 4\delta^2 / \Gamma^2}$$

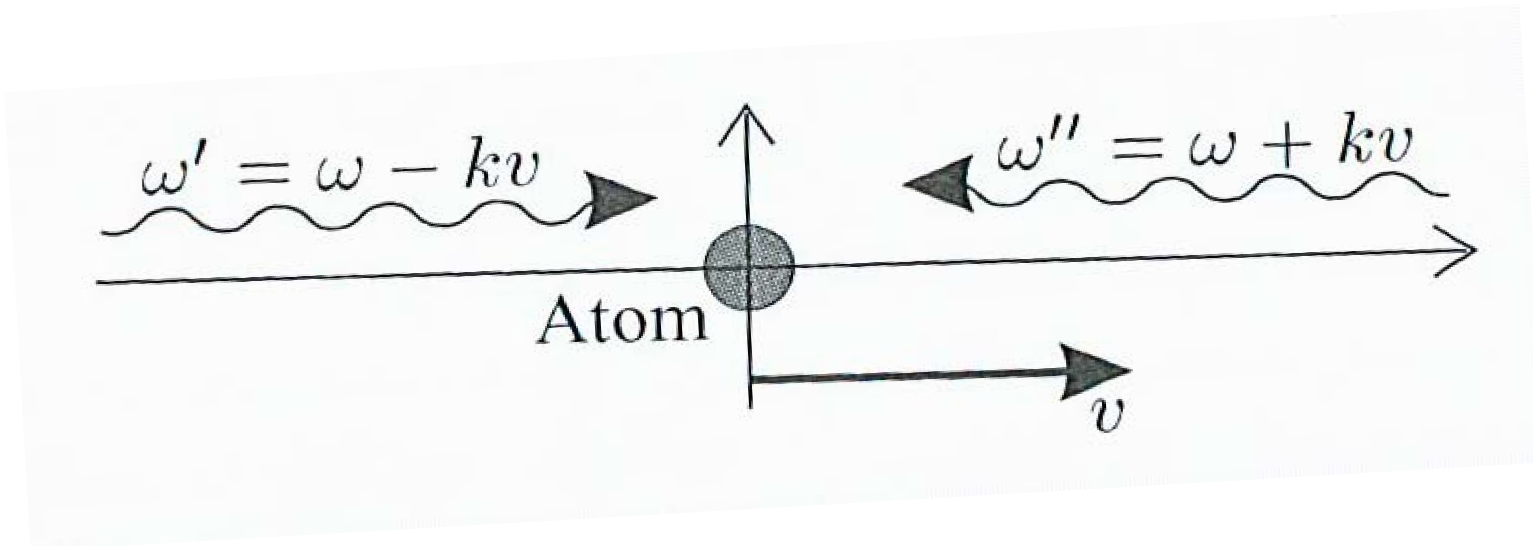


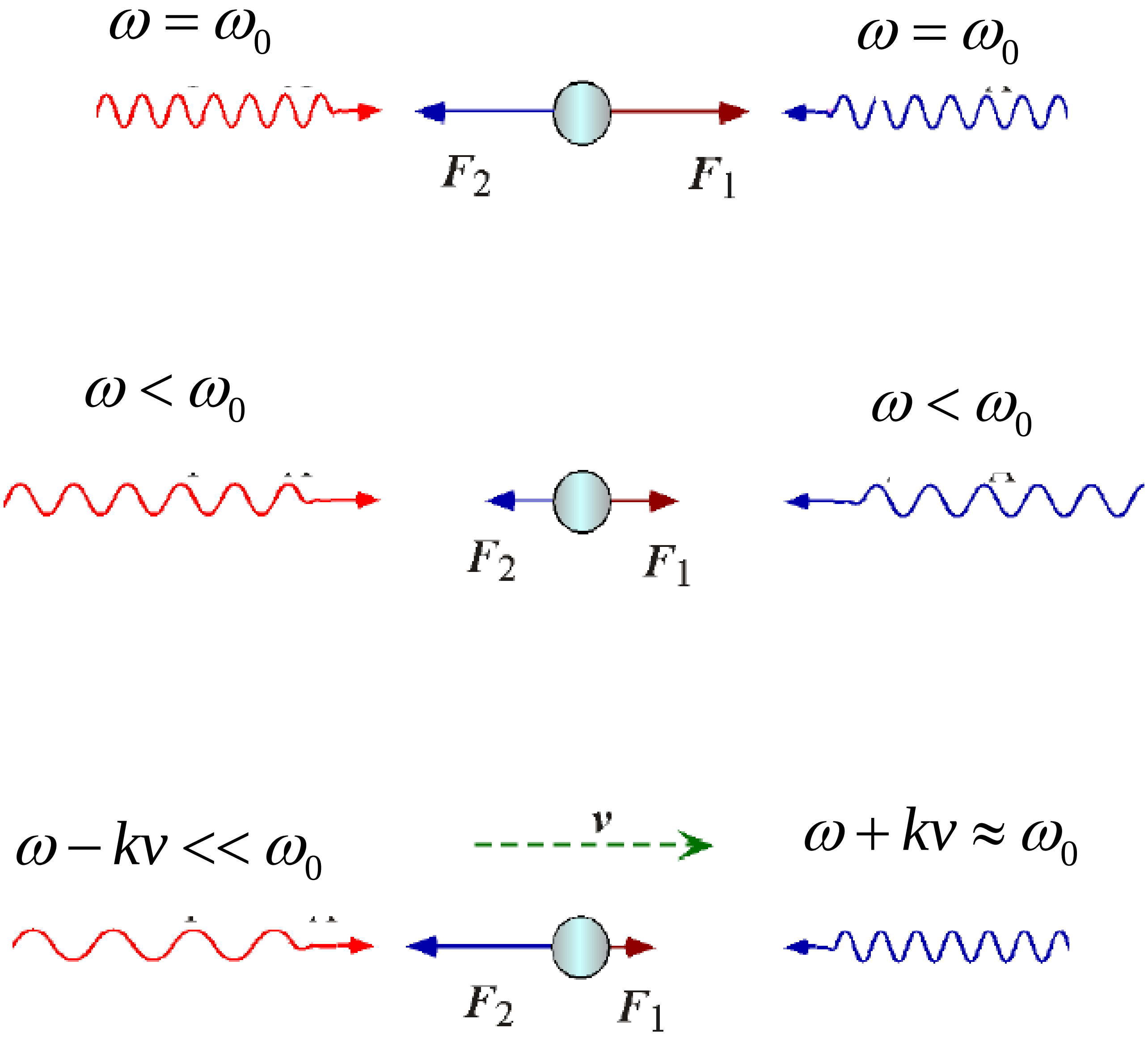
$$a_{\max} = \frac{h}{\lambda M 2\tau}$$



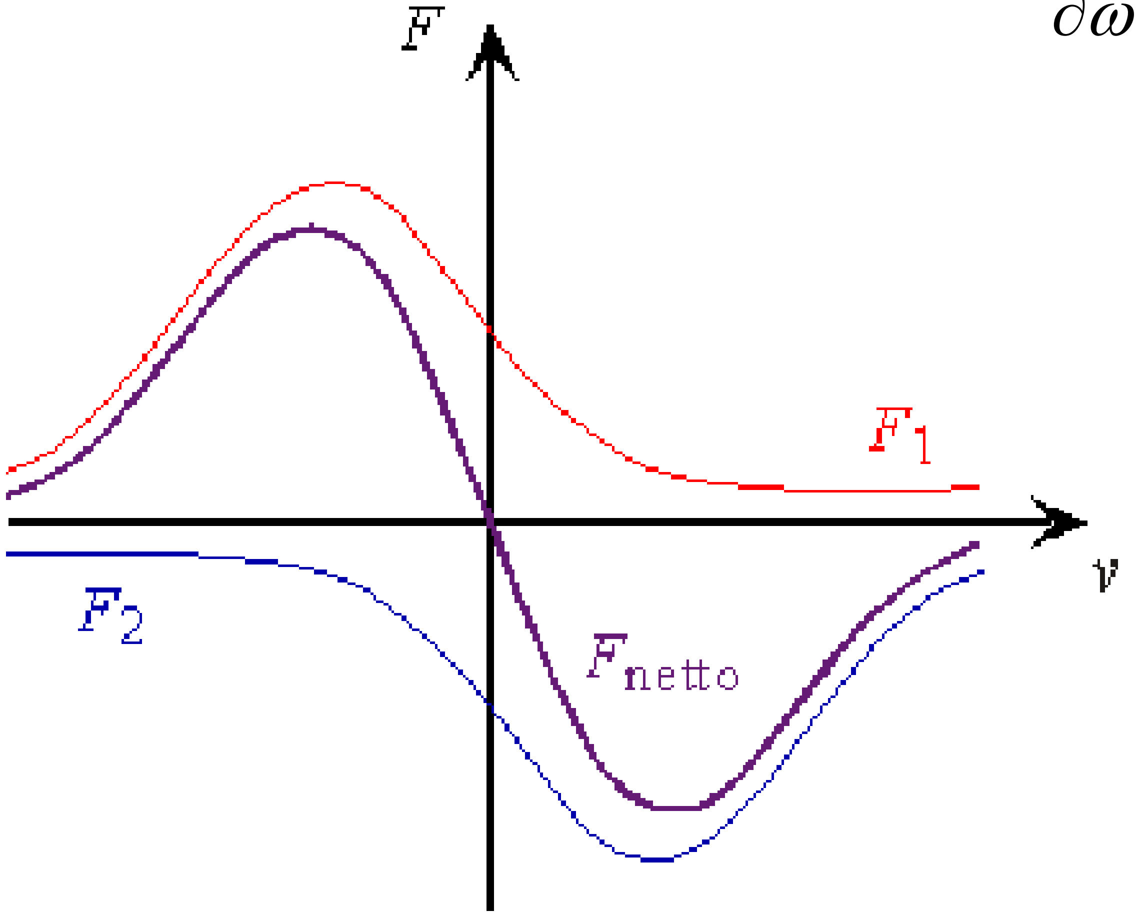

Oven
v
Laser
F_{scatt}

Doppler effect

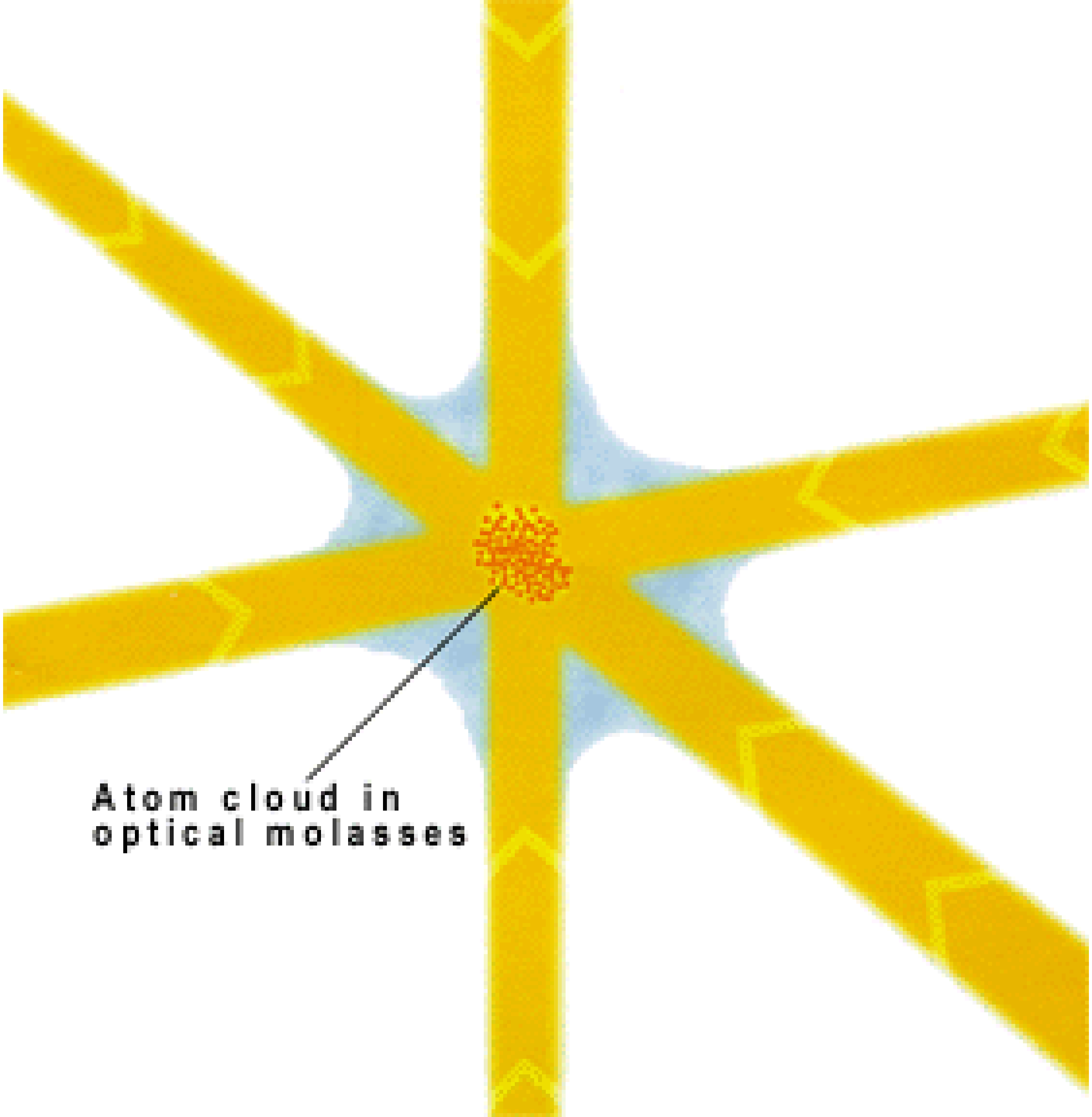


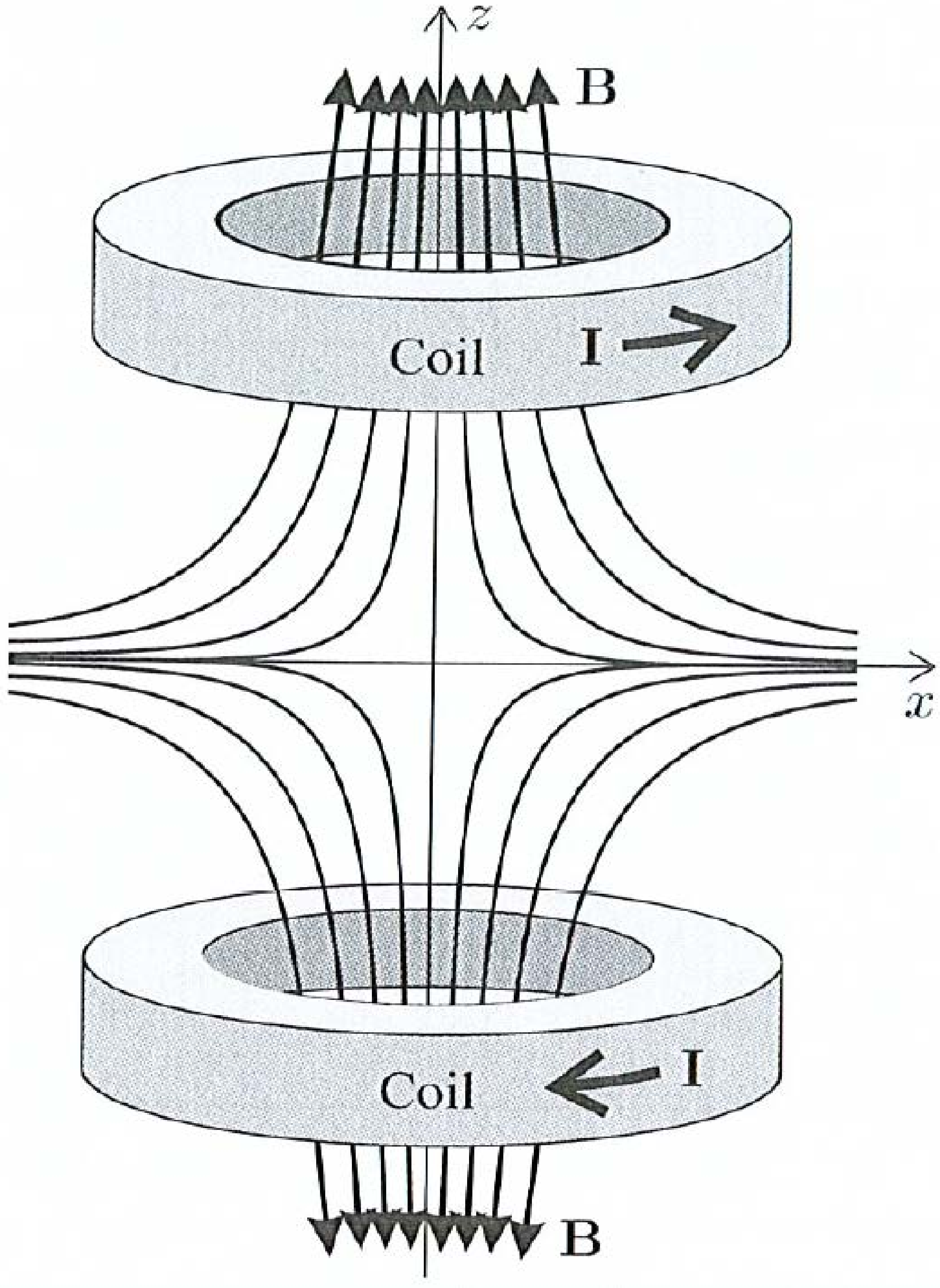

$\omega = \omega_0$
$\omega = \omega_0$
F_2
F_1
$\omega < \omega_0$
$\omega < \omega_0$
F_2
F_1
$\omega - kv << \omega_0$
v
$\omega + kv \approx \omega_0$
F_2
F_1

$$F_{molasses} = F_{scatt}(\omega - \omega_0 - kv) - F_{scatt}(\omega - \omega_0 + kv) \cong -2\frac{\partial F_{scatt}}{\partial \omega}kv \cong -\alpha v$$



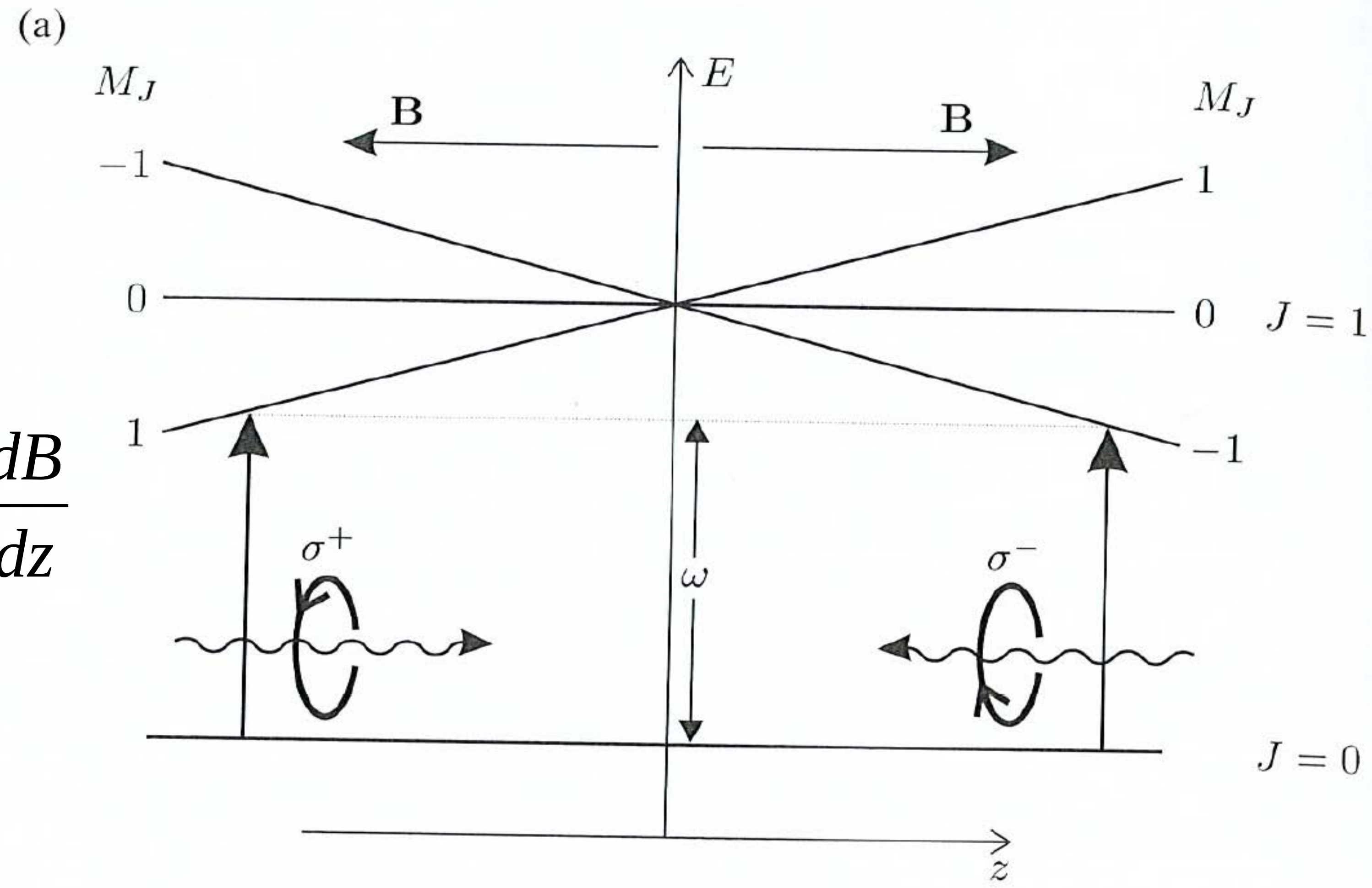
$$\alpha = 2k\frac{\partial F_{scatt}}{\partial \omega} = 4\hbar k^2 \frac{I}{I_{sat}} \frac{-2\delta / \Gamma}{\left[1 + 4\delta^2 / \Gamma^2\right]^2}$$


Atom cloud in
optical molasses



z
B
Coil
I
x
Coil
I
B

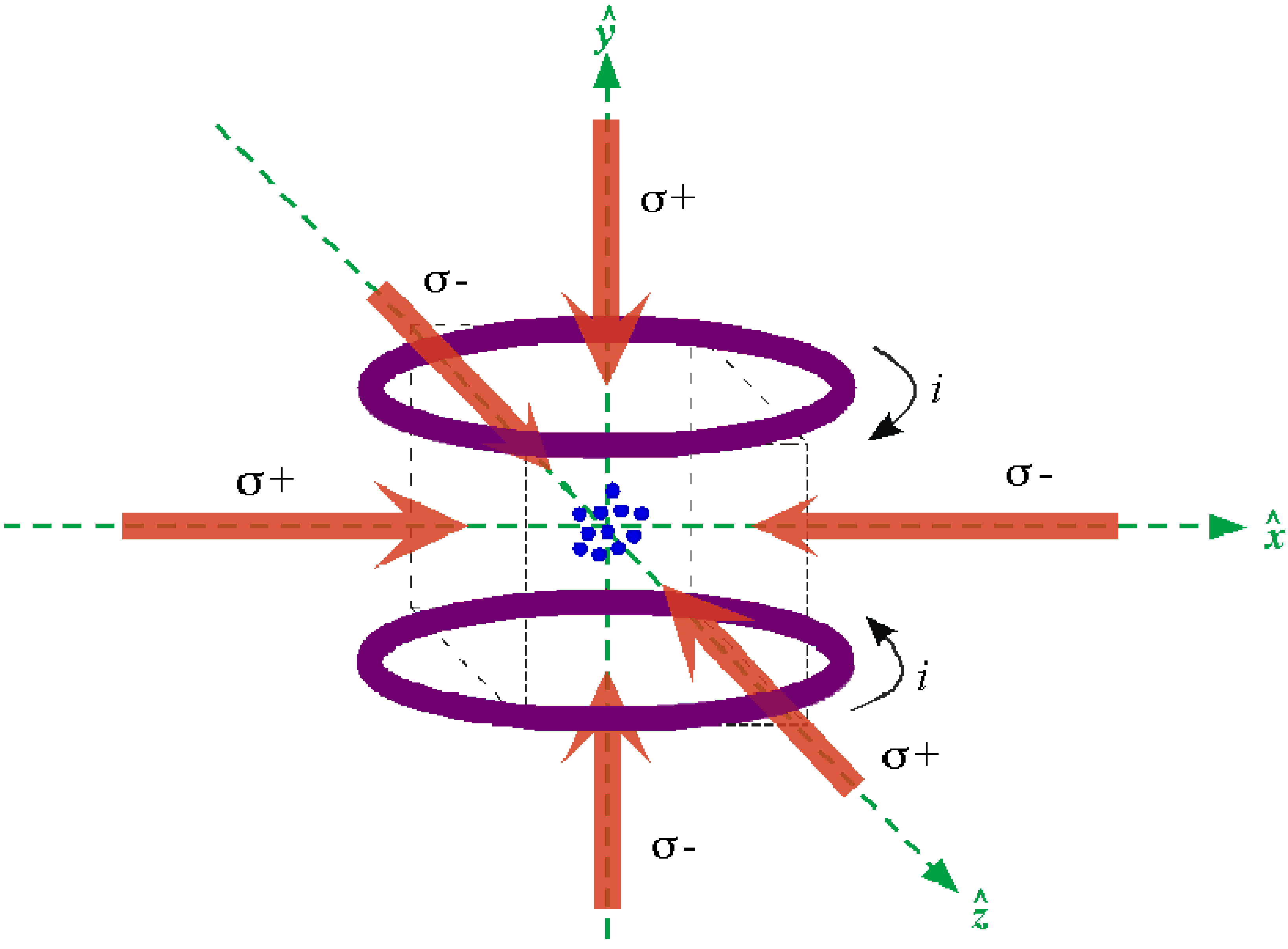
MOT



$$\beta = \frac{g_J \mu_B}{\hbar} \frac{dB}{dz}$$

$$F_{MOT} = F_{scatt}^{\sigma^+}(\omega - kv - (\omega_0 + \beta z)) - F_{scatt}^{\sigma^-}(\omega + kv - (\omega_0 - \beta z))$$

$$\cong -2(kv + \beta z)\frac{\partial F_{scatt}}{\partial \omega} \cong -\alpha v - \frac{\alpha\beta}{k} z$$



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x̂
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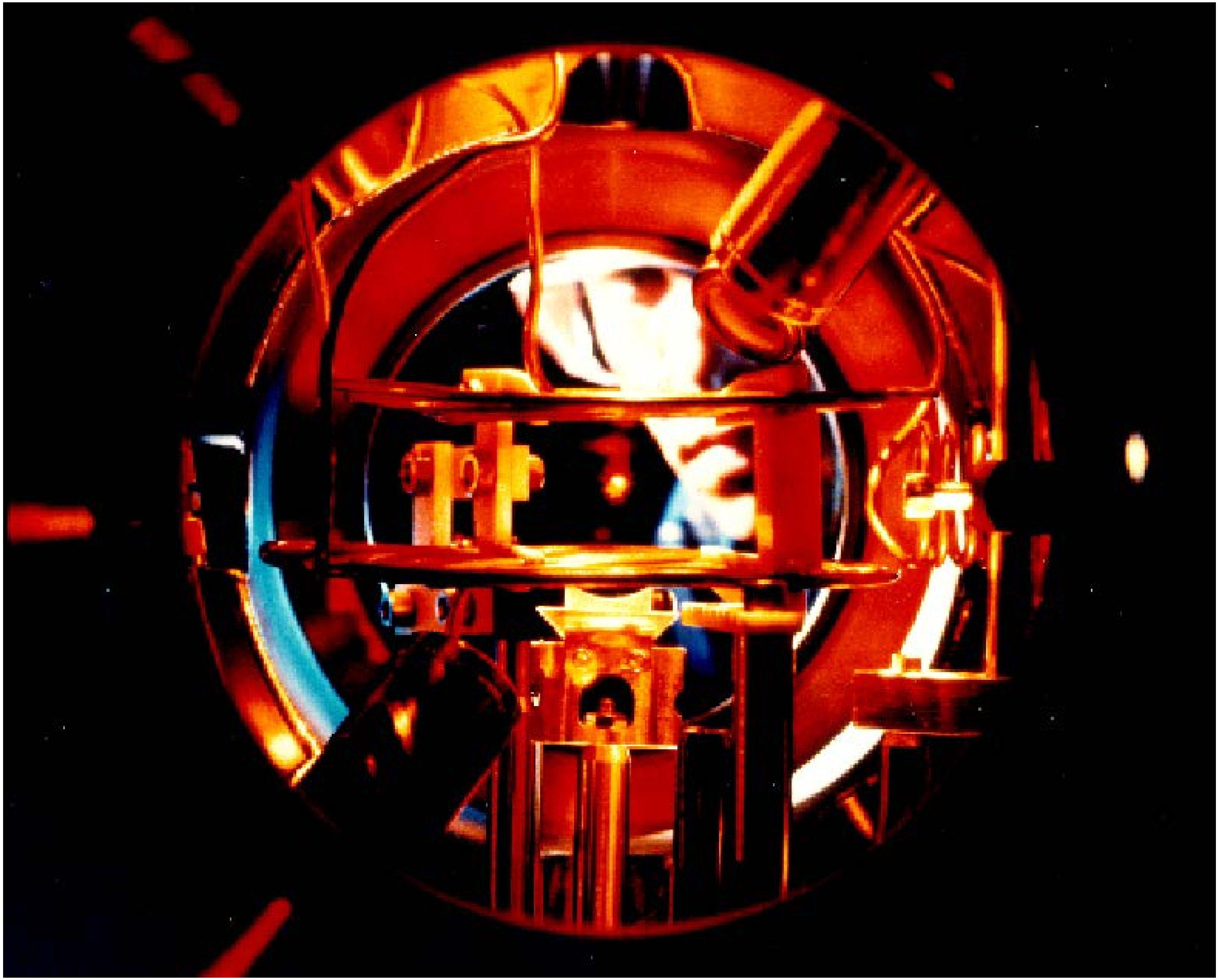
ẑ



able 9.1 Properties of some elements used in laser cooling experiments.

Element	Atomic mass number	Wavelength of resonance (nm)	Lifetime of the excited state (ns)	Doppler temp. (μK)
H	1	121.6	1.6	2400
Li	7	671	27	140
Na	23	589	16	240
K	39	767	26	150
Rb	85, 87	780	27	140
Cs	133	852	31	123