Multiphoton Phenomena

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Overview

1. Multiphoton absorption
2. Other multiphoton processes in atoms
3. Frequency mixing, harmonic generation
4. Parametric down conversion
5. 4 wave mixing
6. Atom optics density modulations, atom interferometer, . . .
7. stimulated Brillouin scattering
8. Phase conjugation (done by 5. or 7.)

Multiphoton Absorption

Lowest order perturbation theory for N-photon absorption:

$$\frac{dP}{dt}(t) = [1 - P(t)]\,\sigma_{(N)}\Phi^N(t) \qquad (1)$$

but: AC Stark shift may shift levels, modify rates

At high fields, atomic levels are irrelevant
Dimensionless EM field amplitude [1]:

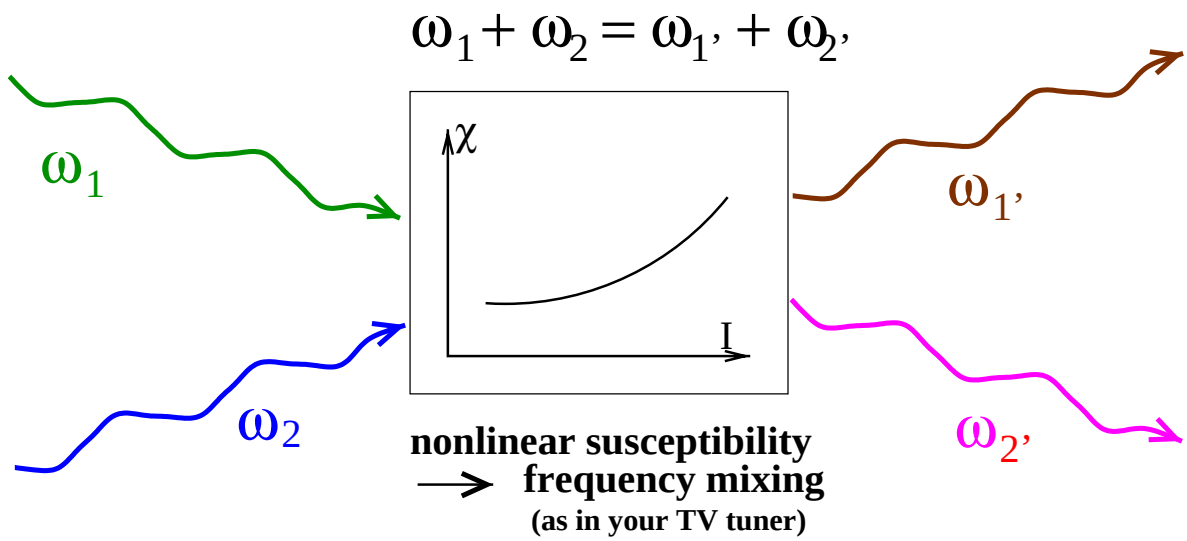
$$a = \frac{e|\mathbf{A}|}{mc^2} \qquad (2)$$

Kinetic energy of electron:

$$\frac{e^2A^2}{2mc^2}, \qquad \mathbf{A_k} = \left(\frac{\hbar}{2\epsilon_0 V\omega_\mathbf{k}}\right)^{1/2} \hat{a}_\mathbf{k}\epsilon_\mathbf{k} \qquad (3)$$

[1] A. Pukhov, J. Meyer-ter-Vehn, Phys. of Plasmas **5** 1880 (1998)

Nonlinear Optics



Nonlinear polarization:

$$P_i = \chi^{(1)}_{ij} E_j + \chi^{(2)}_{ijk} E_j E_k + \chi^{(3)}_{ijkl} E_j E_k E_l + \ldots \qquad (4)$$

$$\chi^{(2)}_{ijk} \left(E_j(\omega_1) E_k(\omega_2) e^{i(\omega_1 \pm \omega_2)t} + \ldots \right) \qquad (5)$$

sum, difference frequency

Energy conservation (temporal phase matching): $\omega_1 + \omega_2 = \omega_{1'} + \omega_{2'}$

Phase matching in space: $\mathbf{k}_1 + \mathbf{k}_2 \approx \mathbf{k}_{1'} + \mathbf{k}_{2'} + \mathbf{H}$

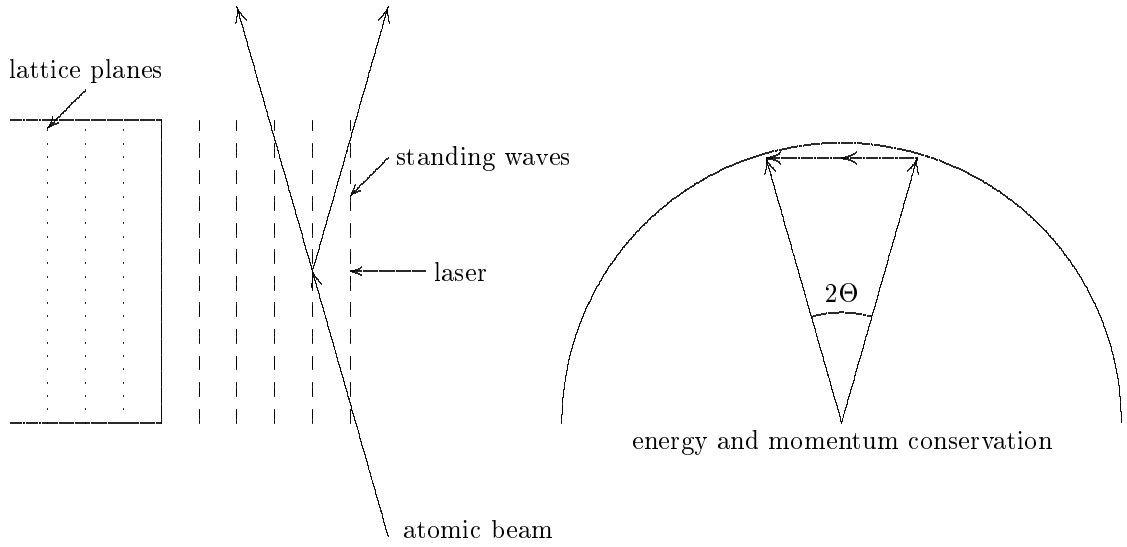
$\approx$ depending on coherence volumes

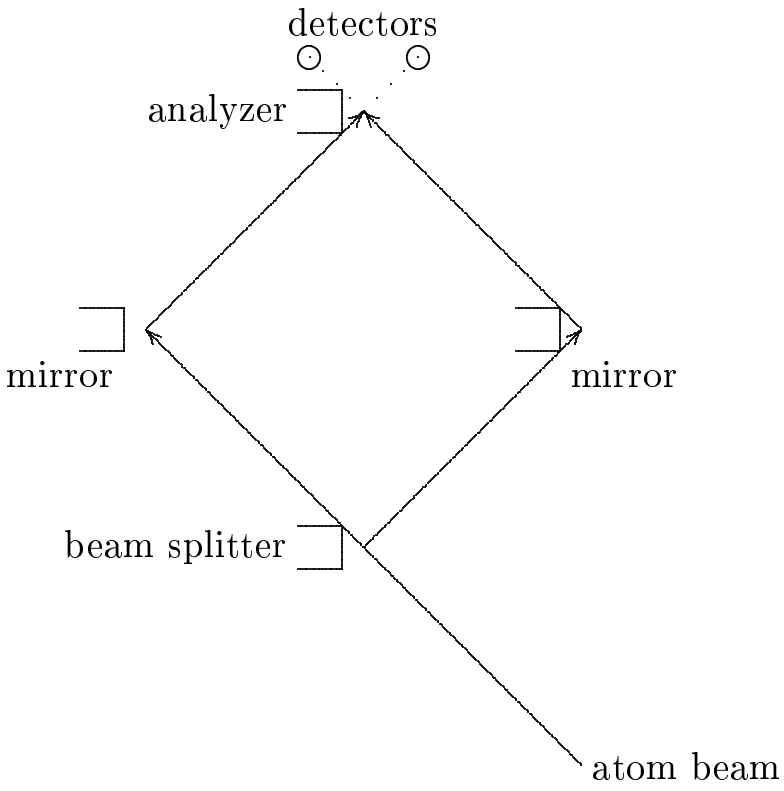
or: momentum transfer between modes in 4 wave mixing

Spontaneous parametric decay if one real, one virtual photon on input side

Atom beam interferometer

P.J. Martin, B.G. Oldaker, A.H. Miklich, D.E. Pritchard, PRL **60**, 515 (1988)



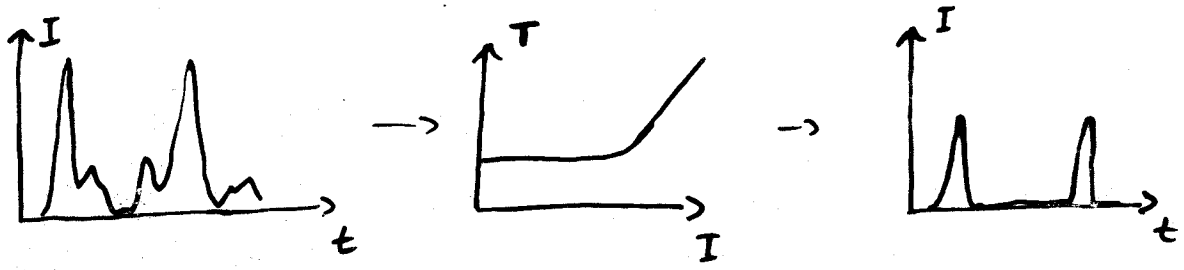


B. Adams, A. Schenzle, in procs. Intl. Workshop X-Ray FEL appl., 16.-17. sept. 1996 at HASYLAB

Modulated Atom beam as Optical Element

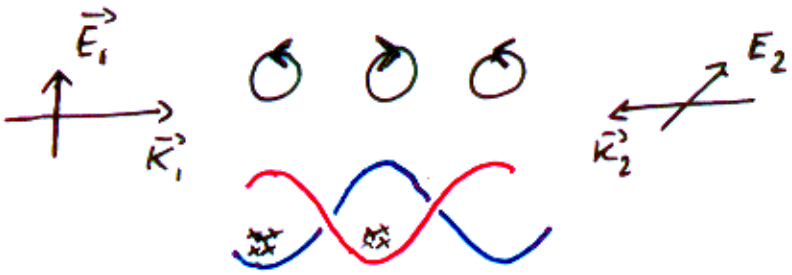
Further Topics

bleachable absorber to select largest spikes

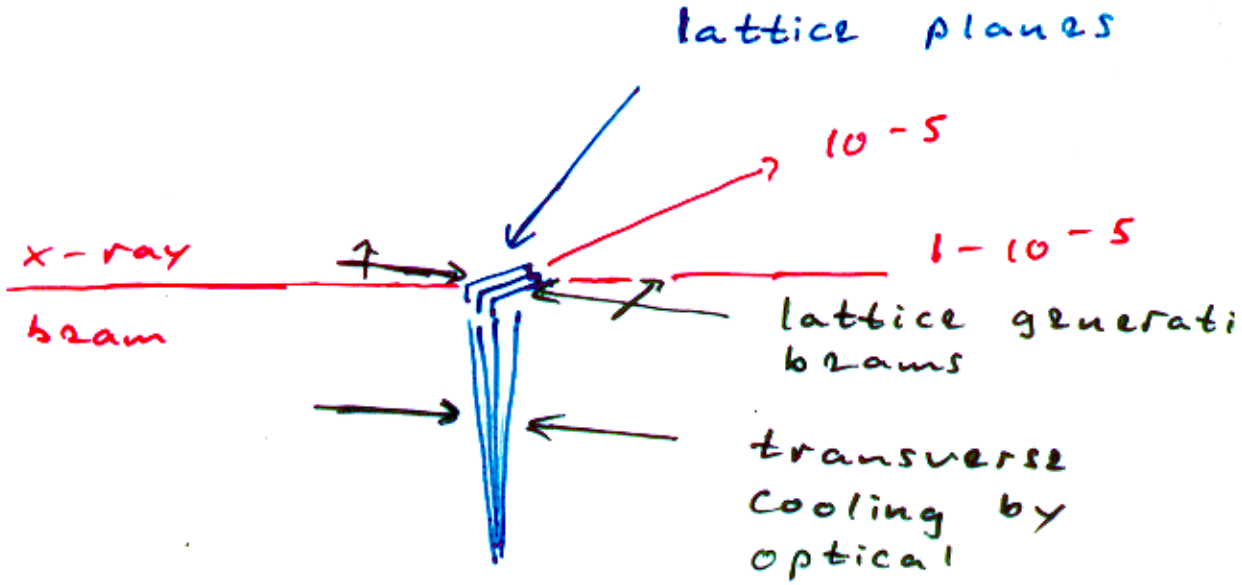


Modulated Atom beam as Optical Element

Laser Induced Lattices as Optical Elements



ponderomotive potential due to Zeeman splitting



B. A. proc. FEL 96
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