ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Non-linear frequency conversion I

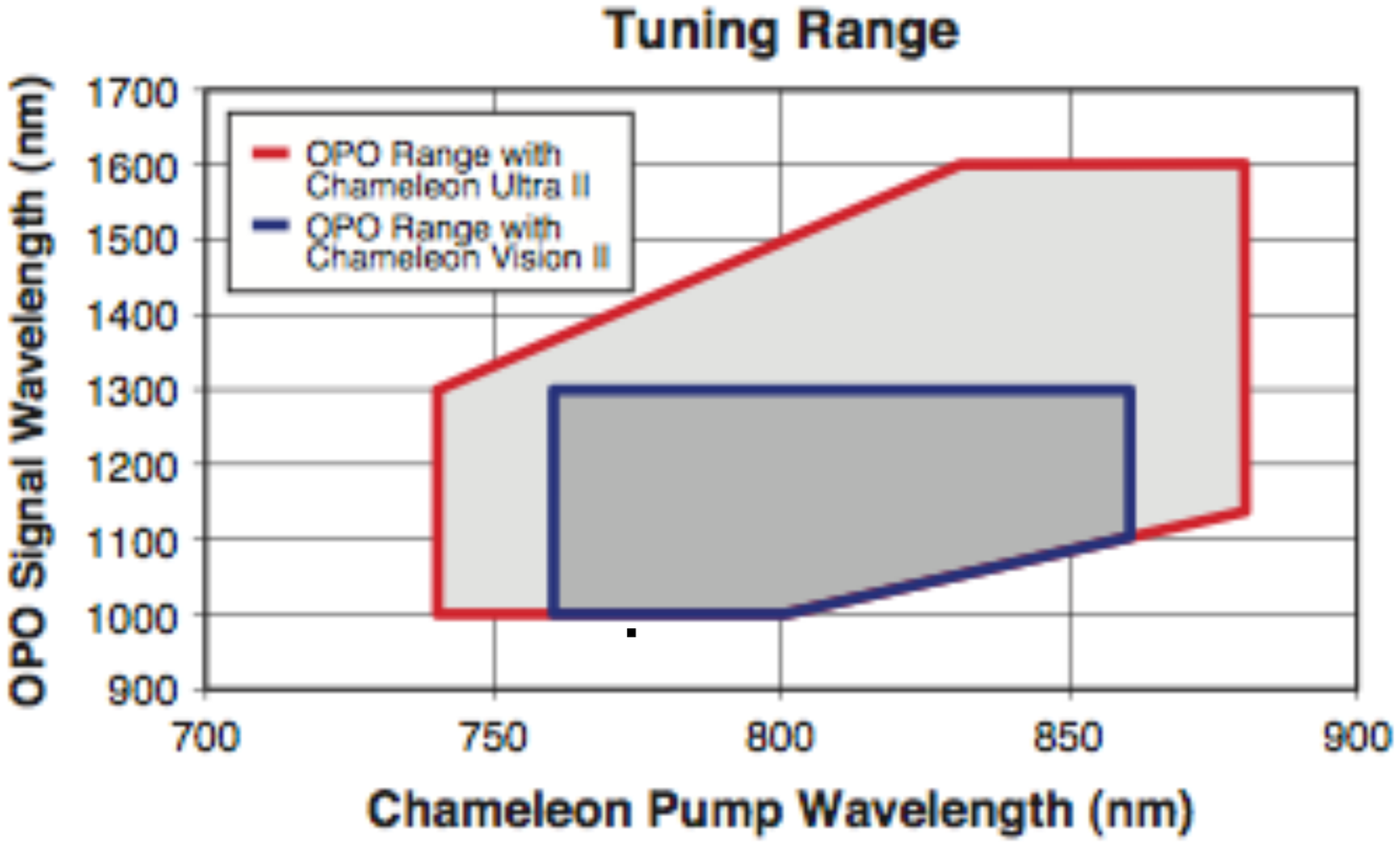
Lasers: theory and applications, lecture 12.1

Christophe Moser

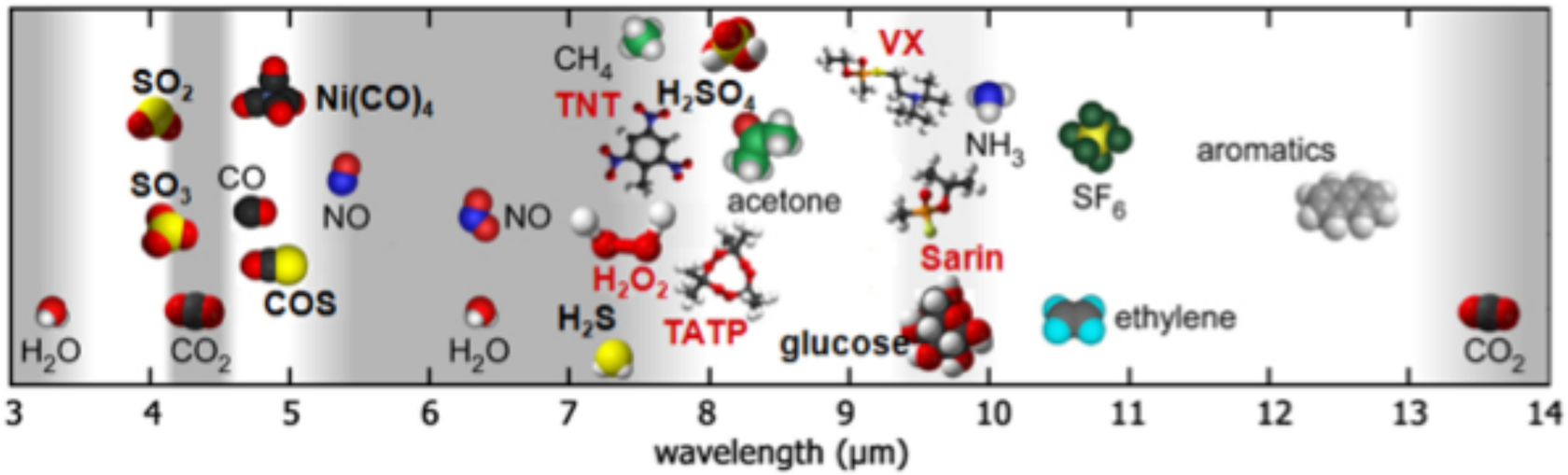
Non-linear frequency conversion I

- Motivation
- Non-linear wave equation

Motivation

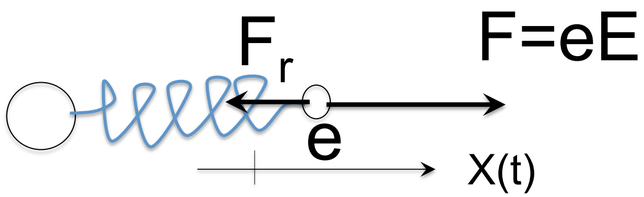

Tuning Range
OPO Range with Chameleon Ultra II
OPO Range with Chameleon Vision II
OPO Signal Wavelength (nm)
1700
1600
1500
1400
1300
1200
1100
1000
900
700
750
800
850
900
Chameleon Pump Wavelength (nm)

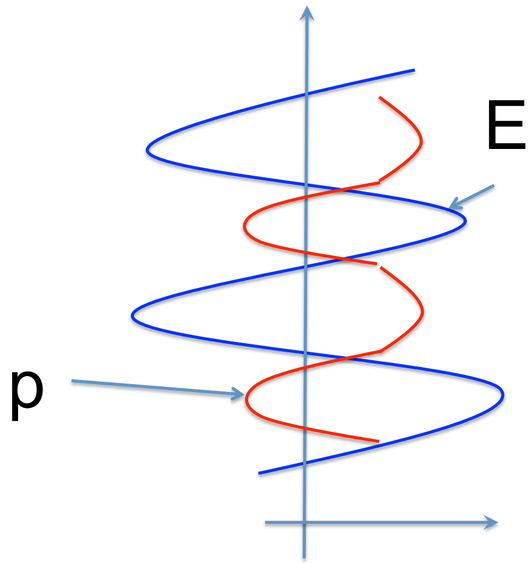
Motivation


SO2
Ni(CO)4
CH4
TNT
H2SO4
VX
NH3
SO3
CO
NO
NO
acetone
SF6
aromatics
H2O2
Sarin
COS
H2O
CO2
H2O
H2S
TATP
glucose
ethylene
CO2
3
4
5
6
7
8
9
10
11
12
13
14
wavelength (μm)

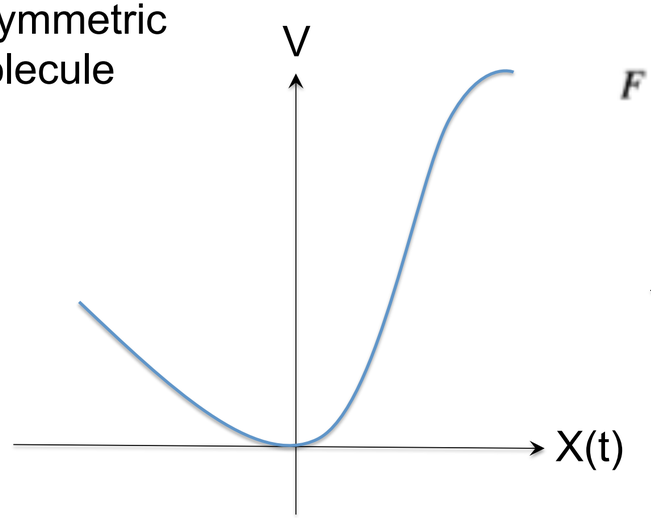
Physical origin

$$p(t) = -Nex(t)$$

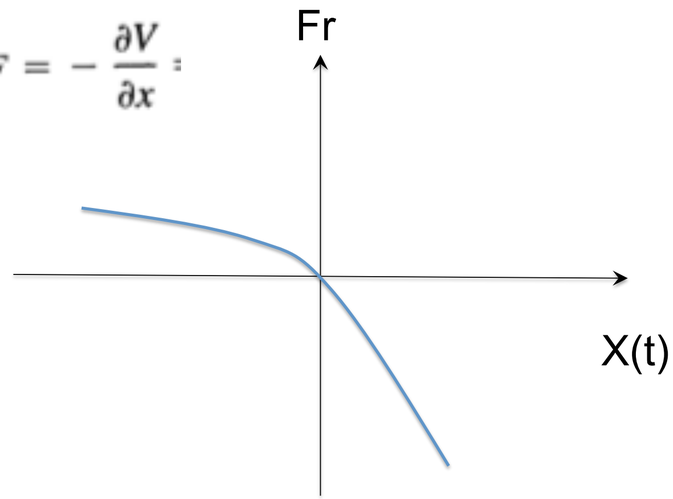


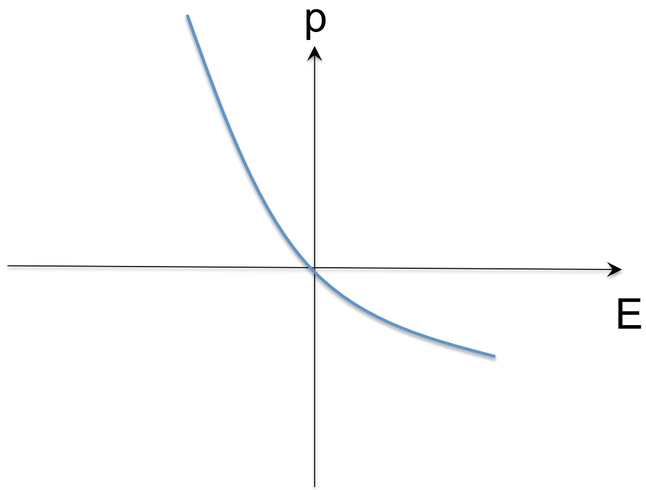


Asymmetric Molecule

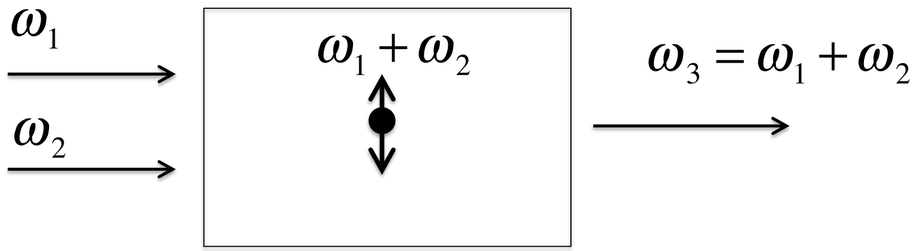


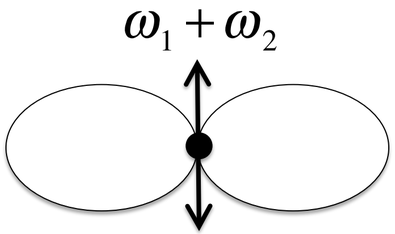
$$F = -\frac{\partial V}{\partial x}$$:

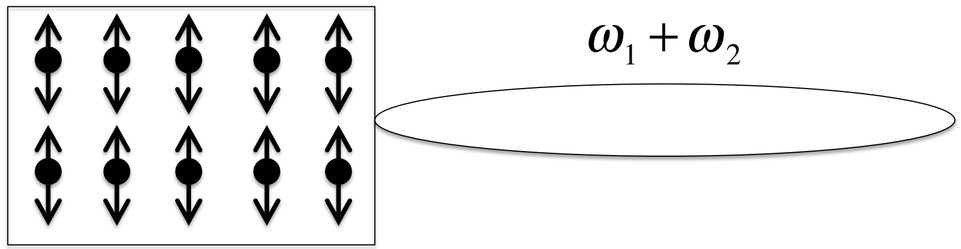




Wave equation







Polarizability P:

$$\nabla^2\vec{E} - \frac{1}{c^2}\frac{\partial^2\vec{E}}{\partial t^2} = \frac{1}{\varepsilon_o c^2}\cdot\frac{\partial^2\vec{P}}{\partial t^2}$$

$$\mathbf{P} = \varepsilon_0\left(\underbrace{\chi^{(1)}\cdot\mathbf{E}}_{\vec{P}^L} + \underbrace{\chi^{(2)}:\mathbf{EE} + \chi^{(3)}\vdots\mathbf{EEE} + \cdots}_{\vec{P}^{NL}}\right),$$

$$\nabla^2\vec{E} - \frac{1}{c^2}\frac{\partial^2\vec{E}}{\partial t^2} - \frac{\varepsilon_o\chi^{(1)}}{\varepsilon_o c^2}\frac{\partial^2\vec{E}}{\partial t^2} = \frac{1}{\varepsilon_o c^2}\cdot\frac{\partial^2\vec{P}^{NL}}{\partial t^2}$$

$$= \varepsilon^{(1)} = n^2$$

$$\nabla^2\vec{E} - \frac{1+\chi}{c^2}\frac{\partial^2\vec{E}}{\partial t^2} = \frac{1}{\varepsilon_o c^2}\cdot\frac{\partial^2\vec{P}^{NL}}{\partial t^2}$$

n and khi depend on optical frequency