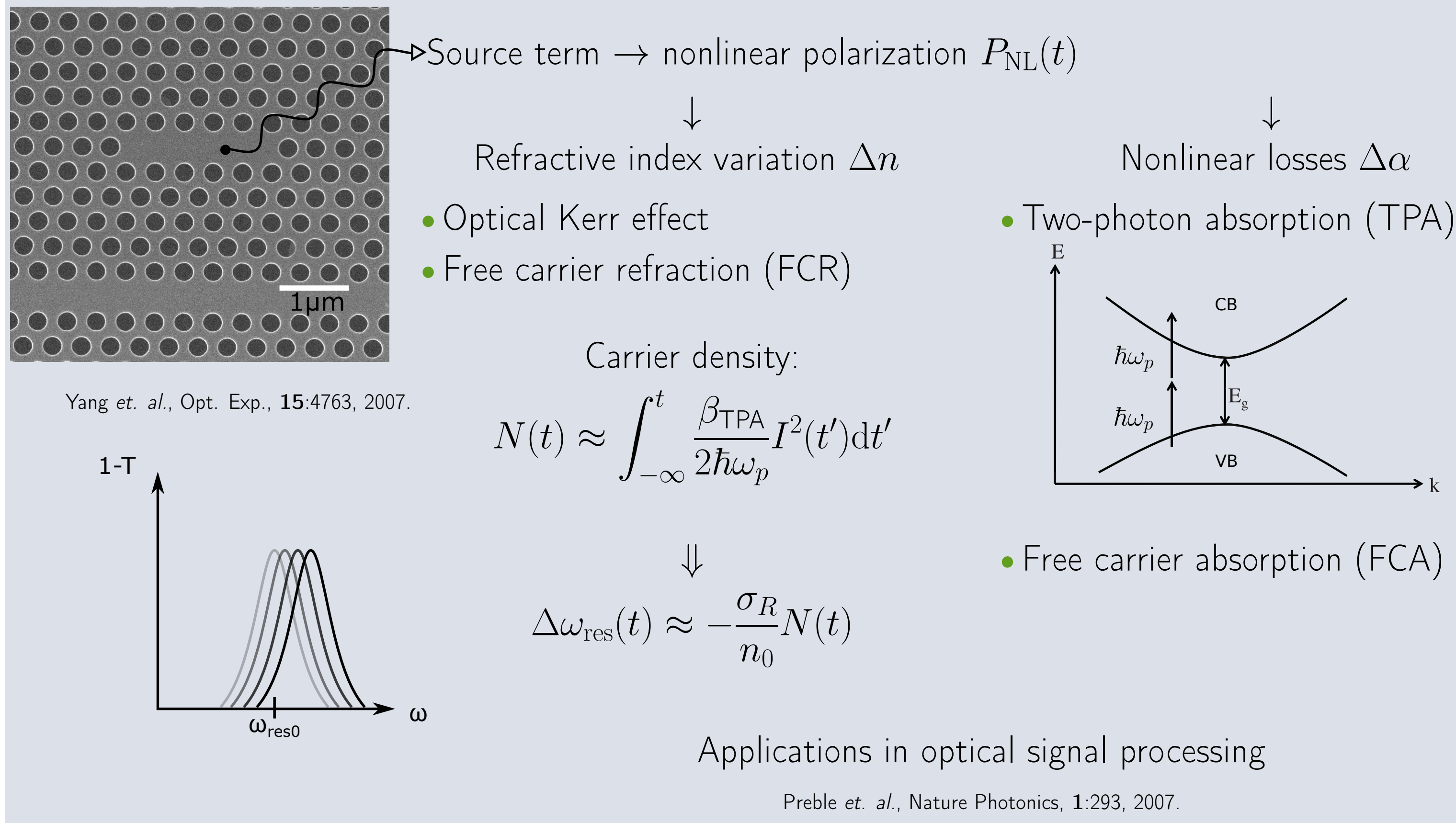


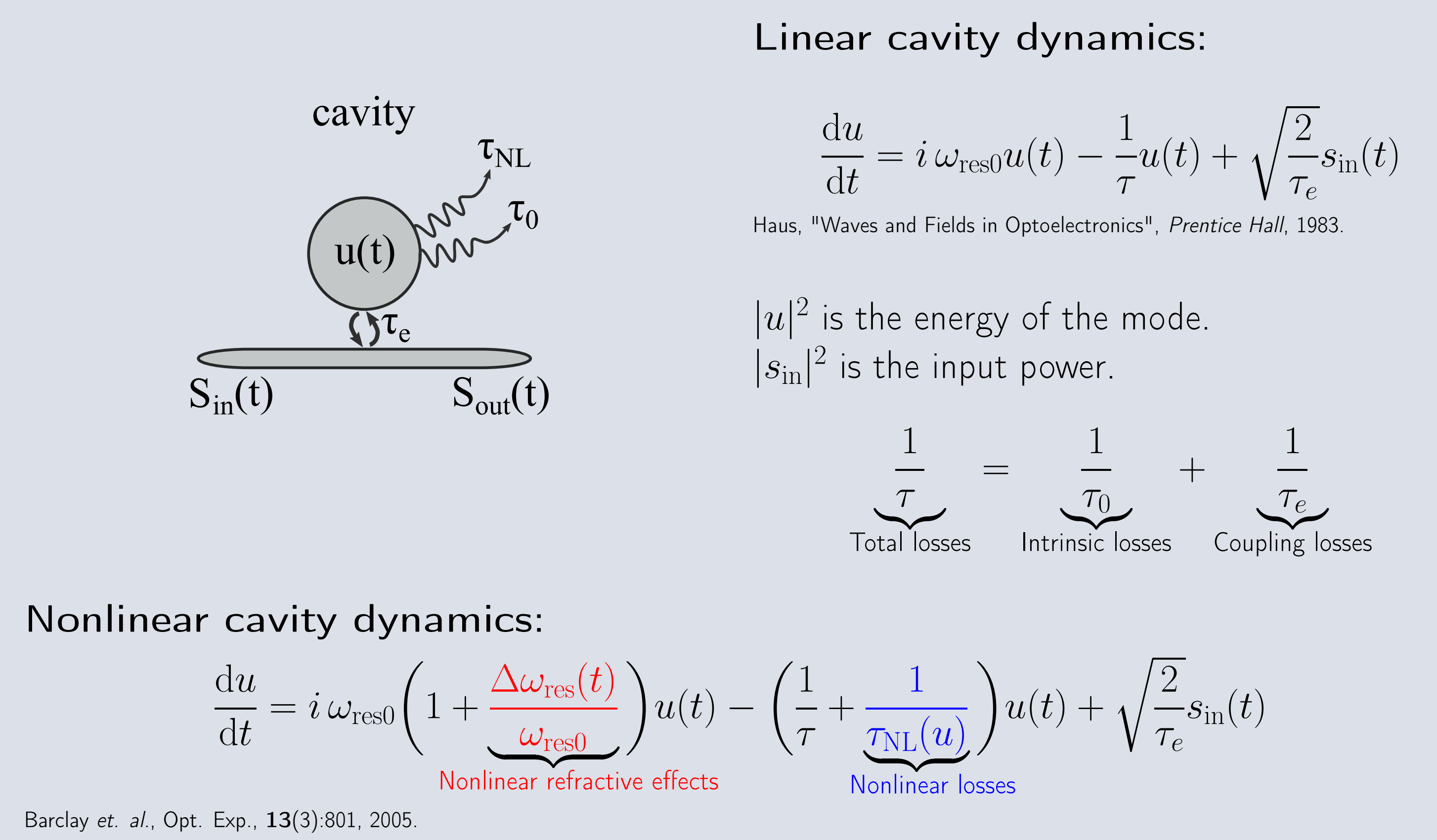
Context

The high magnification factor of photonic crystal microcavities make them useful for all-optical on-chip devices applied to signal processing. In these cavities, the electromagnetic field strengthening, which leads to an enhancement of the non-linearities, induces nonlinear losses and a frequency drift of the cavity resonance. Thus, during the excitation, a mismatch between the resonance and the pulse frequency appears and induces a ringing phenomenon which limits the energy coupled inside the cavity. In order to overcome this limitation, we present here the dynamic behaviour of nonlinear microcavity under a coherent excitation. Similarly to the coherent control of molecular and atomic systems, it uses an excitation pulse with a controlled phase shape. Numerical simulations have been conducted on a semiconductor GaAs microcavity operated around 1550 nm with picosecond pulse duration.

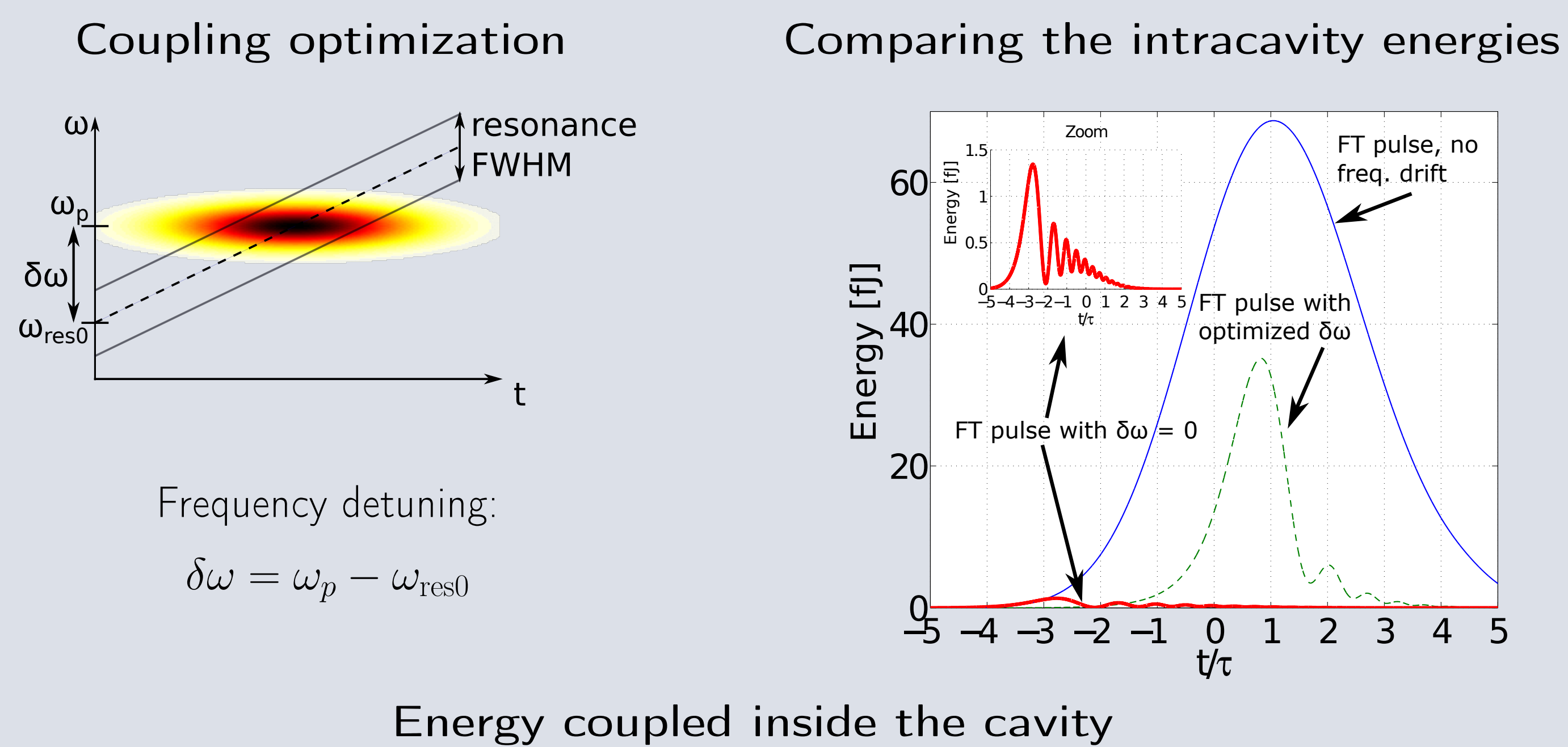
Nonlinear semiconductor microcavities



Nonlinear microcavity model



Simple example: linear resonance frequency drift

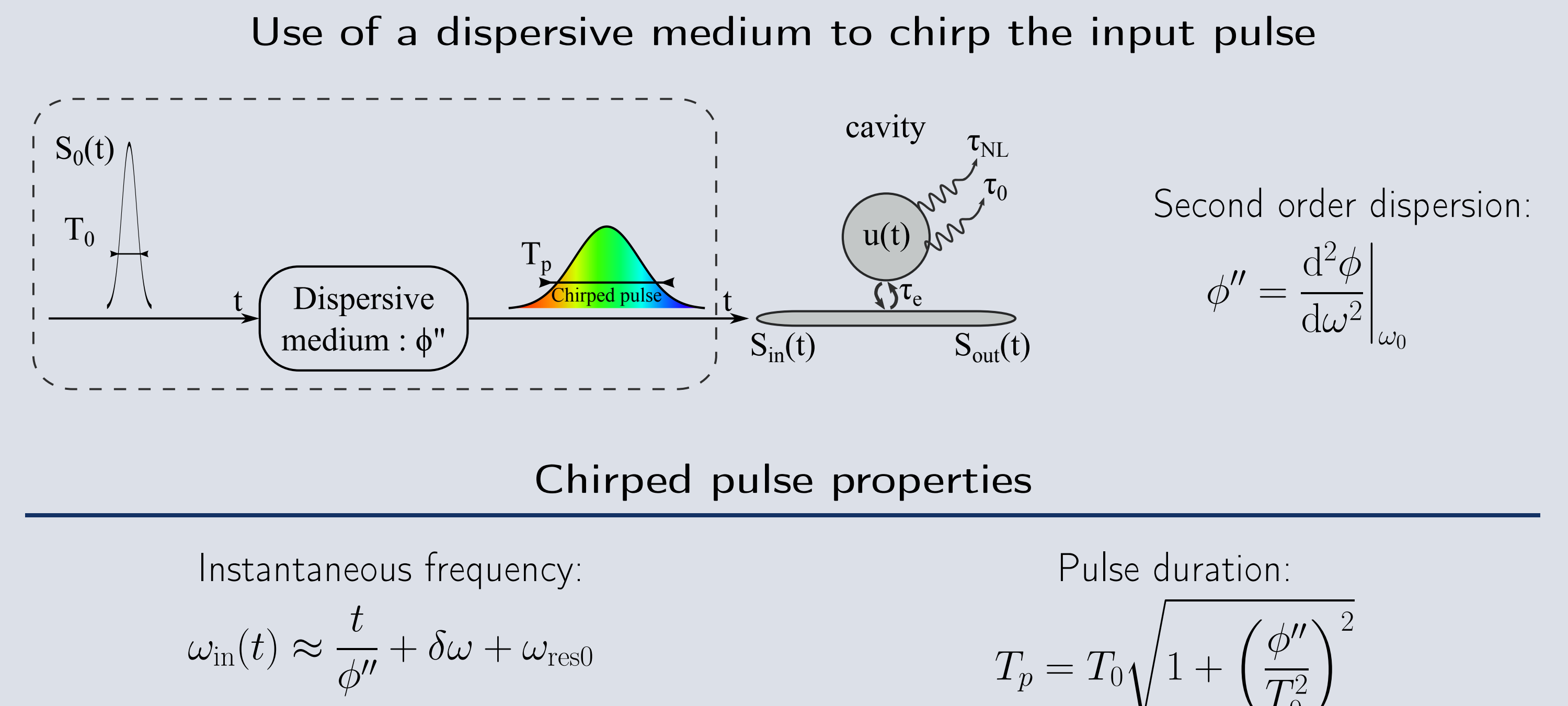


$$\frac{d|u|^2}{dt} + \frac{2}{\tau}|u(t)|^2 = 2\sqrt{\frac{2}{\tau_e}}|u(t)| \cdot |s_{in}(t)| \cdot \cos[\phi_u(t) - \phi_{in}(t)]$$

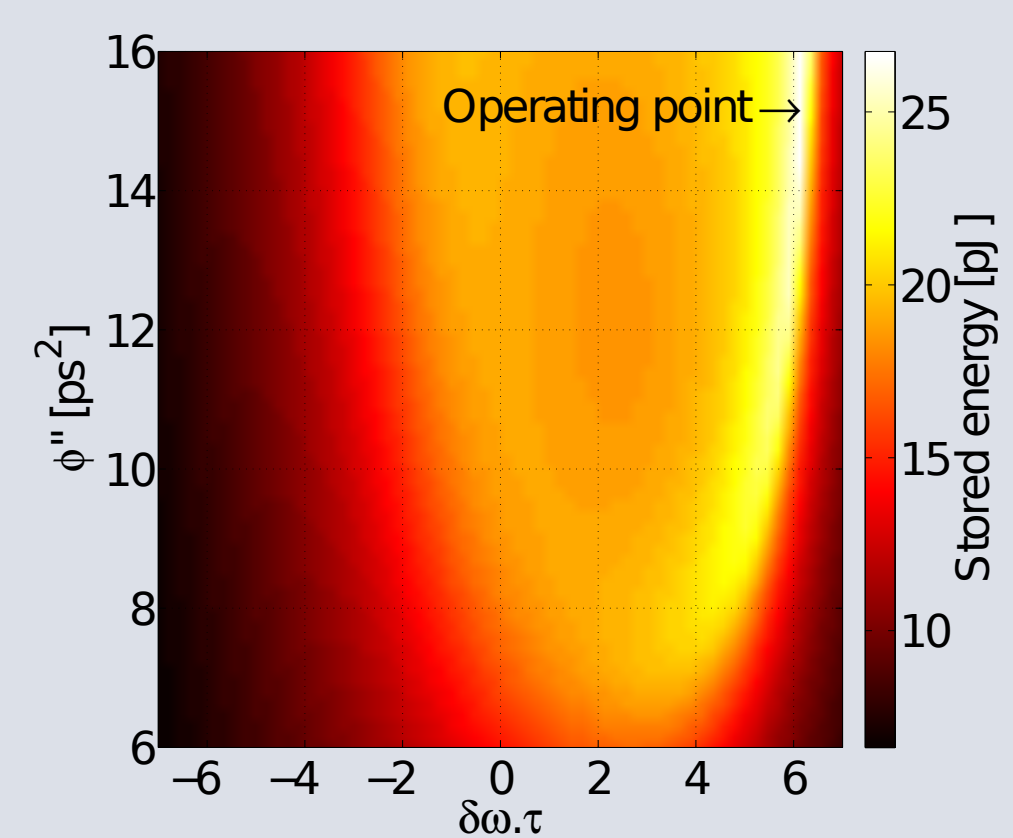
Ioannidis et. al., Opt. Lett., 13:422, 1988.

The coupled energy is reduced by a beating between the intracavity chirped field (which experiences the nonlinear effects) and the input signal.

Coherent excitation of a nonlinear GaAs microcavity



Maximizing the stored energy



The stored energy is defined as:

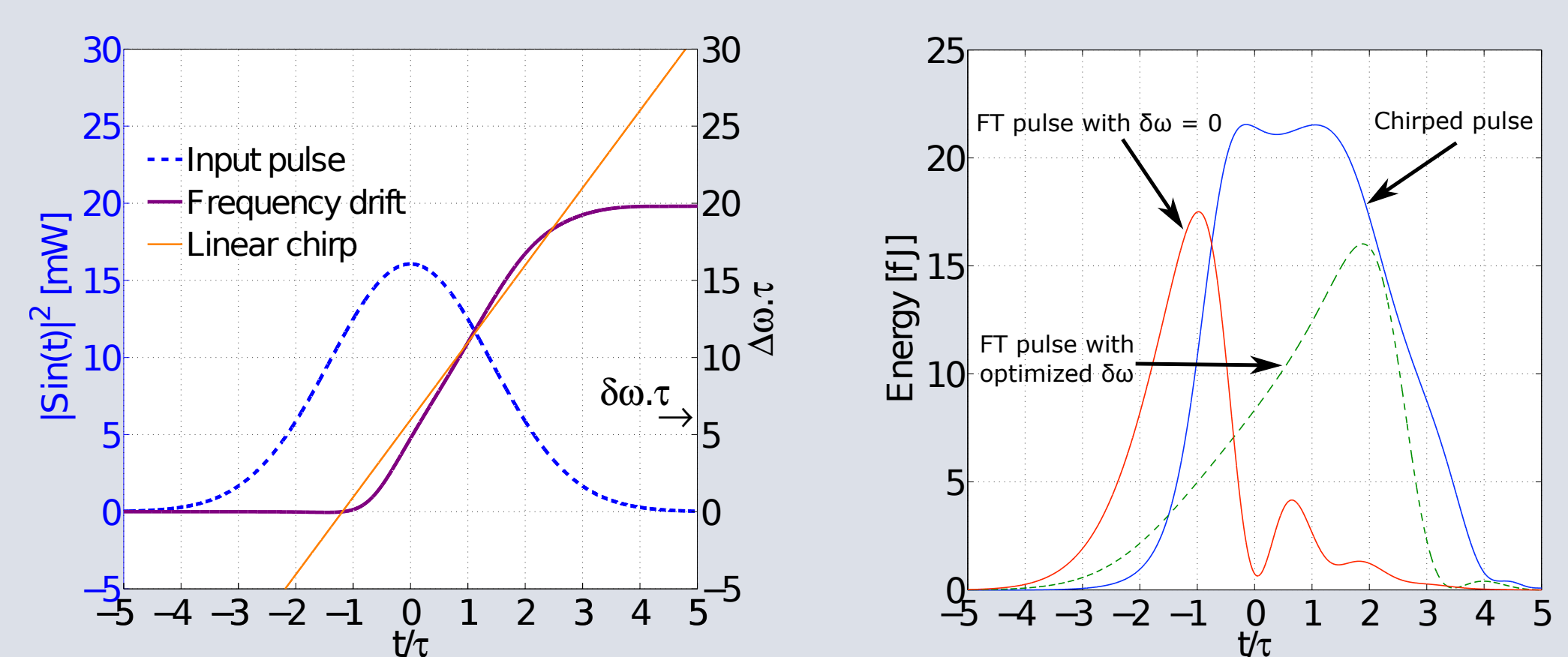
$$\mathcal{E}_{stored} = \frac{1}{\tau_R} \int_{-\infty}^{+\infty} |u(t)|^2 dt,$$

where τ_R is the round-trip time.

Simulation results:

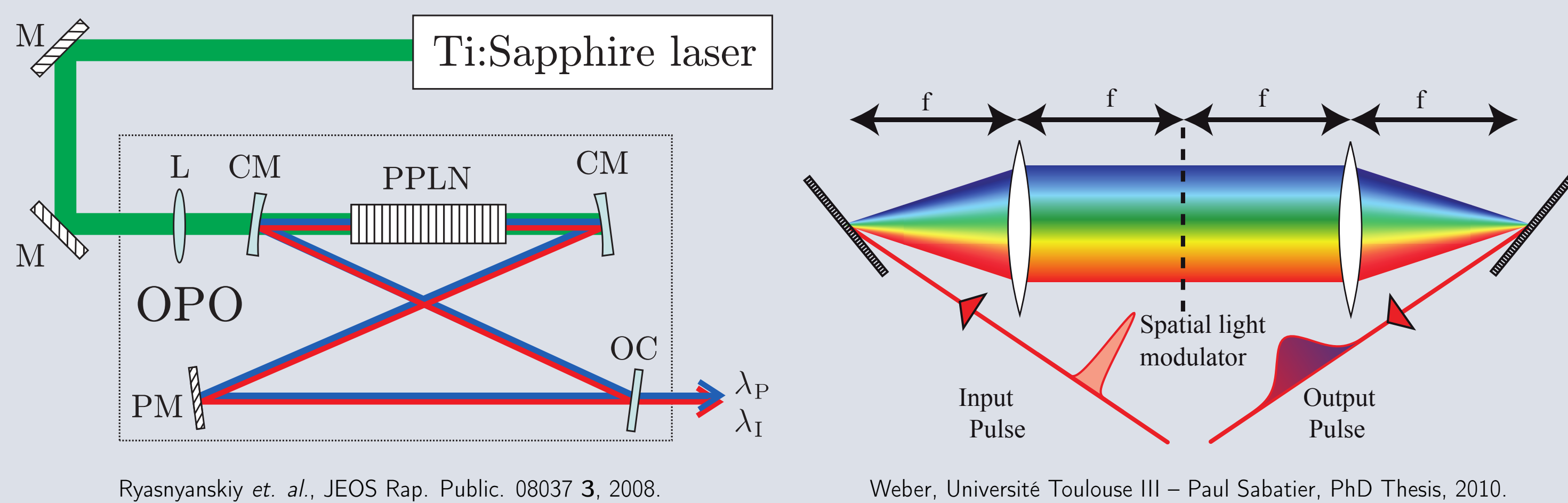
- $\phi'' = 15.37 \text{ ps}^2$
- $\delta\omega = 6.11/\tau$
- $T_p = 2 \cdot \tau$

Oden et. al., Opt. Exp., to be submitted, 2012.



- 240% more stored energy compared to a Fourier-Transform pulse initially on resonance
- 75% more stored energy compared to a Fourier-Transform pulse with an optimized detuning
- Nonlinear effects enhanced: 4 and 2 times more FCR

Experimental setup



Two OPOs delivering picosecond Fourier-Transform pulses are used to realize a pump-probe experiment.

Conclusions, future work

We have shown that a phase shaping of the pulses allows to control the dynamics of a nonlinear microcavity. In our case, this method is used to maximize the stored energy, but it can be employed for other applications – for instance, to control the dynamics of a set of coupled microcavities. The more important point is that the dynamics is controlled by the phase relation carried by the excitation beam. The next step is to demonstrate experimentally the efficiency of this method on a GaAs microcavity, in a picosecond regime.