PARAMETRIC INSTABILITY IN CONICAL OPTICAL RESONATORS

LSC-meeting QND-workshop report

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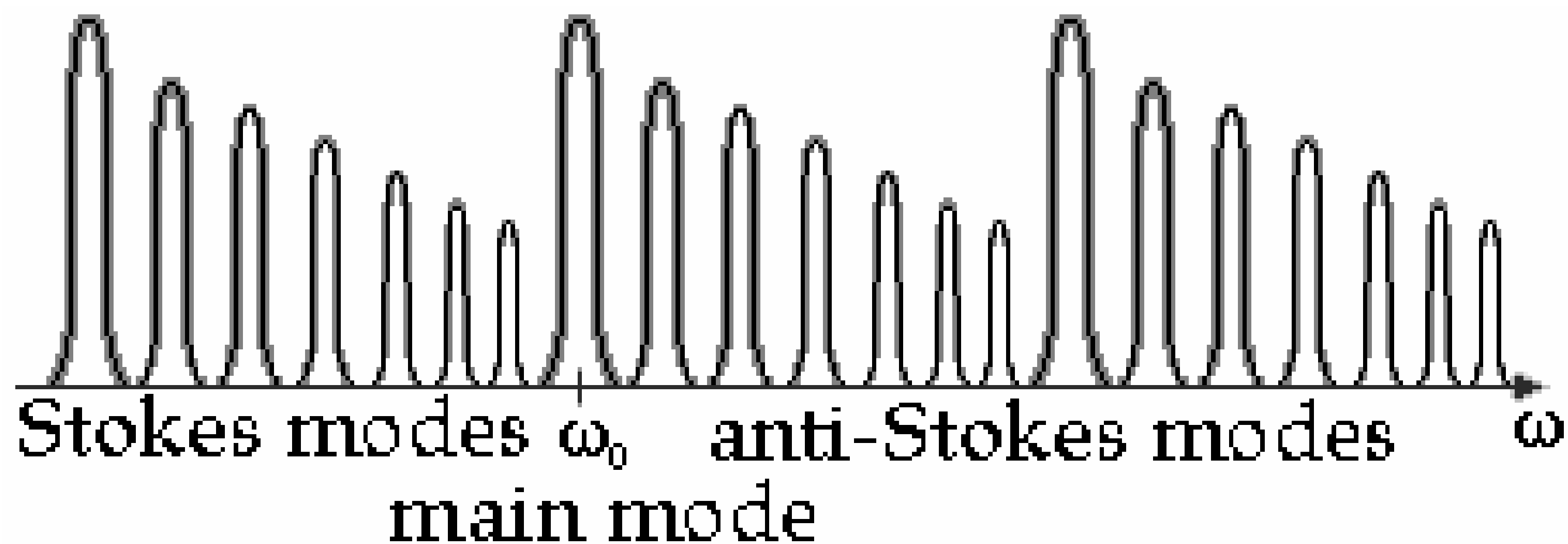
Interferometer Modes

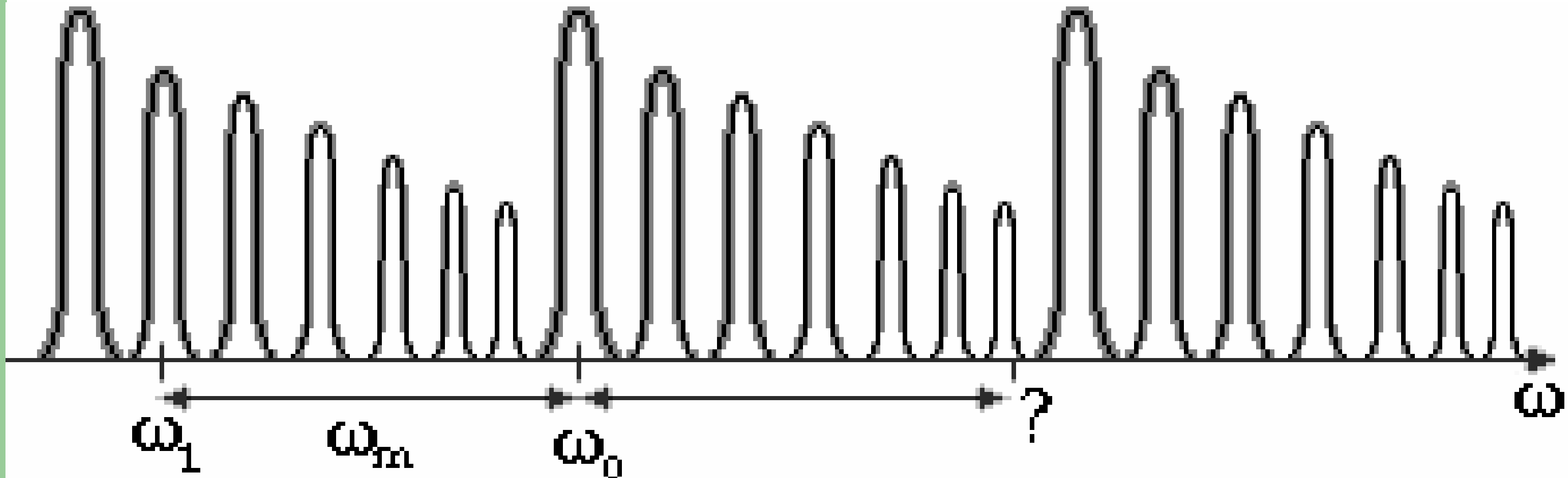


- the pumped mode is called *the main mode*, it's frequency is ω_0
- the modes with frequency $\omega<\omega_0$ are called *Stokes modes*
- the modes with frequency $\omega>\omega_0$ are called *anti-Stokes modes*

Parametric Instability

For us parametric instability means excitation of Stokes mode with frequency ω_1 and mirror mechanical mode with frequency ω_m when energy, stored in main mode with frequency ω_0 is big enough and detunig $\Delta=\omega_0-\omega_1-\omega_m$ is small.

Usually there is reliable Stokes mode but there is no reliable anti-Stokes mode, which can supress instability. This case is considered.



Works on Parametric Insatability

The idea belongs to prof. S.P Vyatchanin and prof. V.B. Braginsky:

V.B. Braginsky, S.E. Strigin and S.P. Vyatchanin "Parametric oscillatory instability in Fabry–Perot interferometer ", Phys.Lett.A, v. 287, p. 331-338 (2001)

We used the results of the following article for our numerical calculations:

A.G. Gurkovsky, S.E. Strigin and S.P. Vyatchanin "Analysis of parametric oscillatory instability in signal recycled LIGO interferometer", Phys.Lett.A, v. 362, p. 91-99 (2007)

Parametric Instability Condition

In the last work the following parametric instability condition has been got:

$$\frac{2Q}{\gamma_m \gamma_{0+}} > 1 + \frac{\Delta^2}{(\gamma_m + \gamma_{0+})^2}$$

Where:

$$Q = \frac{\Lambda_1 W \omega_1}{c L \omega_m m}$$

Notations

Where:

- W is the optical power, circulating in arm cavities ,
- c is the speed of light,
- L is the arm cavity length,
- m is the cavity mirror mass,
- γ_m is the mechanical mode relaxation rate,
- γ_{0+} is the Stokes mode relaxation rate, including diffractional loses and cavity influence,
- Λ_1 is the overlapping factor showing the coincidence of optical fields and mechanical osclillations on mirror surface.

Parametric Gain

In our calculations we considered the case that is the best for the parametric instability and the worst for us:

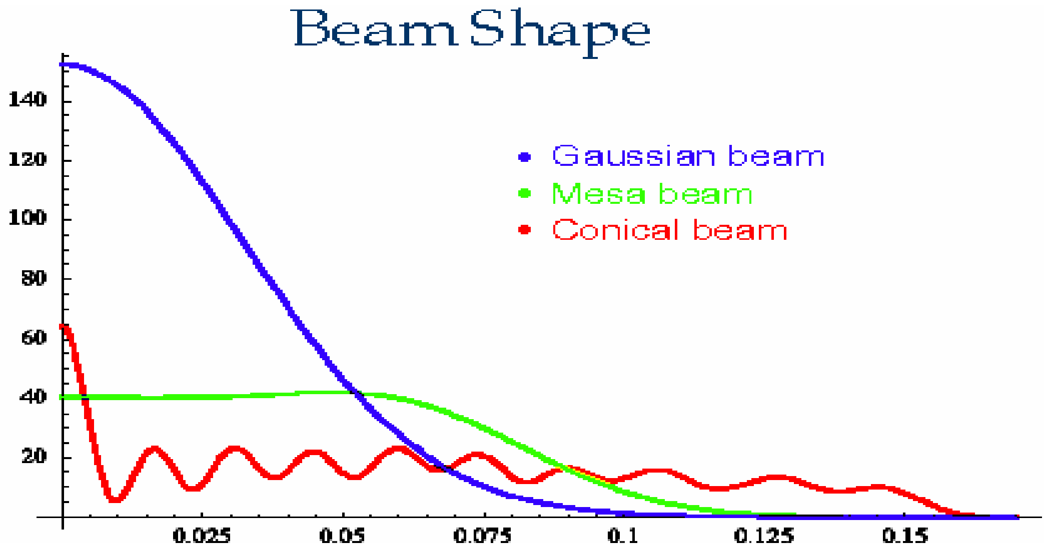
- detuning $\Delta=0$,
- overlapping factor $\Lambda_1=1$,
- there are no diffractional loses in all non-arm mirrors.

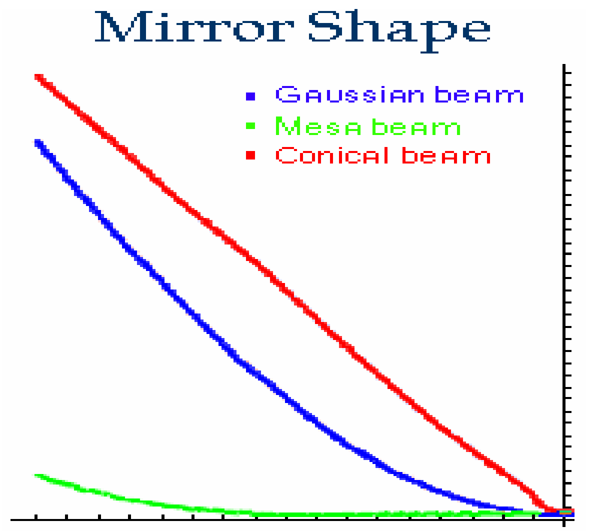
We used *the parametric gain* in our calculations:

$$\mathcal{R} = \frac{2Q}{\gamma_m \gamma_{0+}}$$

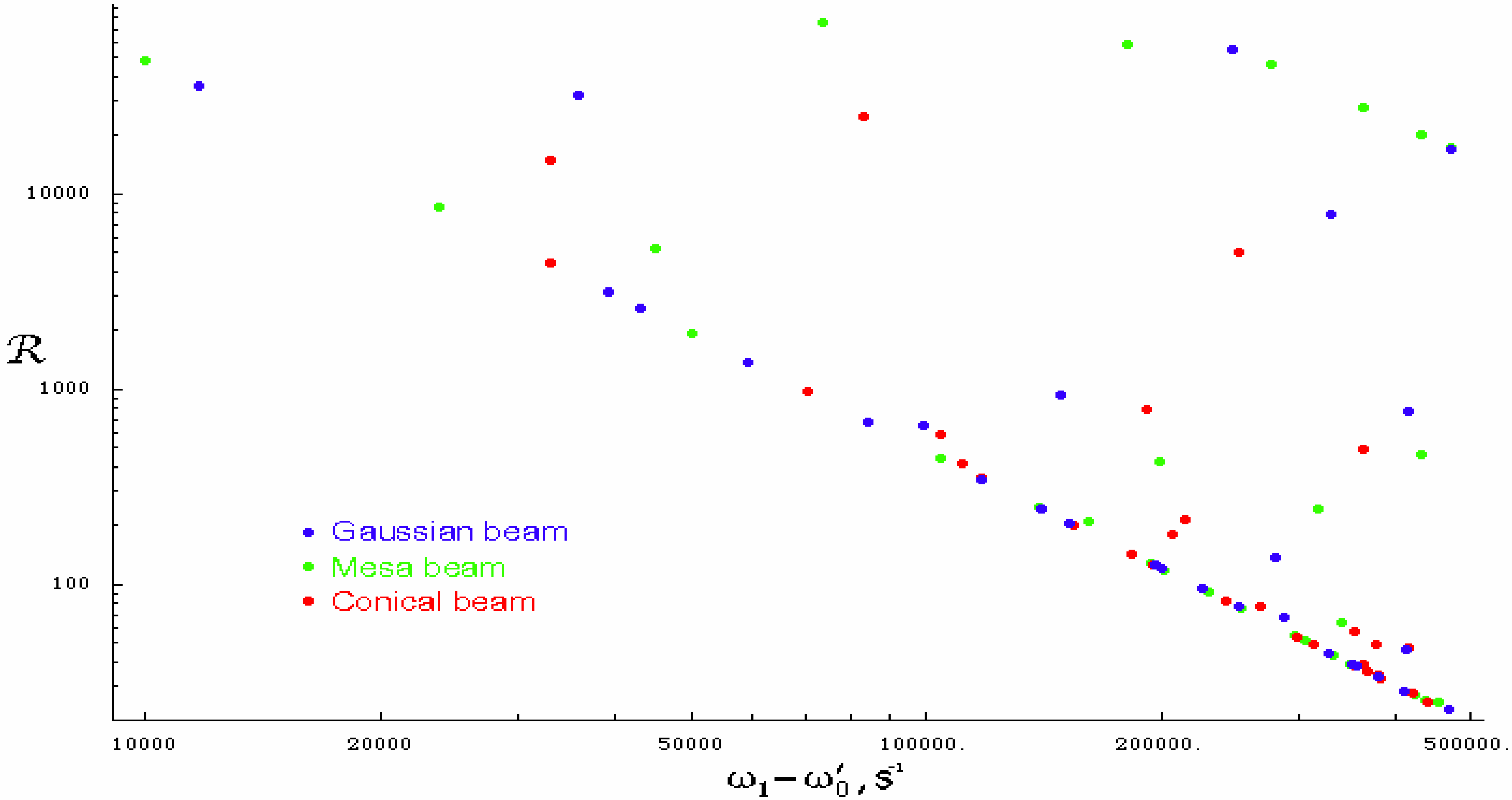
Mirror Shapes and Beams

- Gaussian beam – spherical mirrors;
- Mesa beam – almost spherical mirrors;
- Conical beam – conical mirrors.

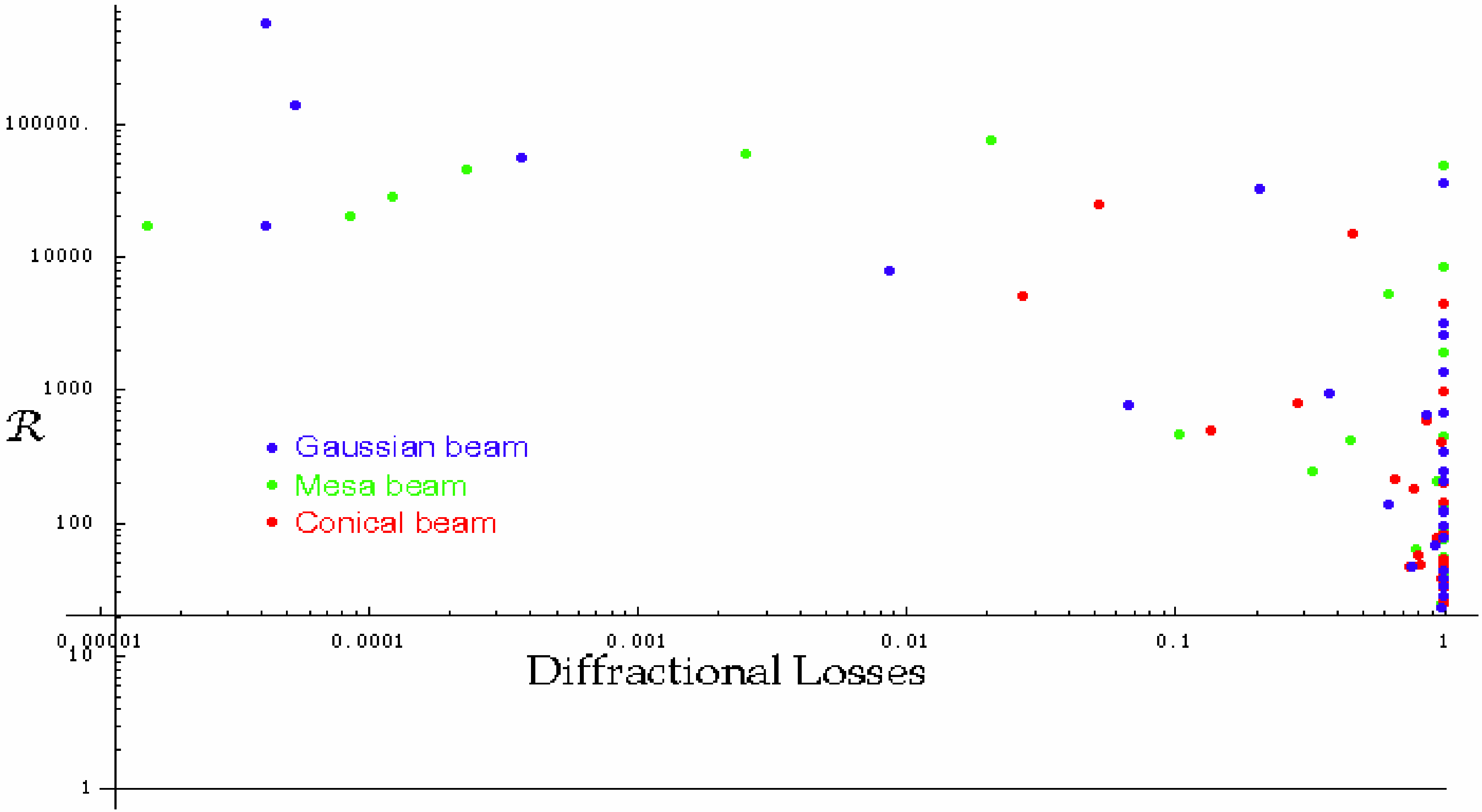




Parametric Instabilities Comparison



Parametric Instabilities Comparison



Conclusions

- as it was though, parametric instbility for conical beam is less dangerouse than for other beams;
- as it was though, parametric instbility is still very dangerouse;
- more valid data may be obtained if the mechanical modes data will be obtained. This is planned now.

THANK YOU FOR YOUR ATTENTION!