New Folder Name <u>Mode Cleaner Mirror Parameters</u>

Mode Cleaner Mirror Parameters

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Corrected Version

Measurements

The following table summarizes the measured properties of the mode cleaner now in place in the 40 meter system.

Parameter	Measurement
Cavity Length l	92.5 cm
Input Mirror Transmission T_1	964 ± 15 ppm
Output Mirror Transmission T_2	969 ± 15 ppm
Cavity Visibility K	0.64 ± 0.04
Cavity Throughput η	0.46 ± 0.02
Energy storage time τ_e	2.62 μsec
3-dB-amplitude frequency f_k	29.2 kHz

Except for T_1 and T_2, these measurements were made within 3 days of cleaning the mirrors on October 10, 1990. The mirror transmissions have not been measured since the mode cleaner was installed in April, 1990, and are assumed to be unchanged. Cavity throughput includes a small correction for several anti-reflection coated surfaces. The storage time is measured by setting the cavity on resonance, cutting off the input light, and monitoring the ringdown of the transmitted light. f_k is the frequency where the cavity output is reduced by 3dB, in response to small modulation of the input intensity. For small modulation, this measurement is sensitive to the amplitude of the field[1].

Calculation

The connection between storage time and knee frequency is $f_k = \frac{1}{4\pi\tau_e}$. This predicts $f_k = 30.4$ kHz, within 4% of the observed value of 29.2 kHz.

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[1]See *Transmission of Optical Power Transients by Fabry-Perot Cavities ...*, M. E. Zucker, October 29, 1990

Assuming equal mirrors, the ratio of transmission to other losses for each mirror is[2]

$$\frac{L}{T} = \frac{1}{2}\left(\frac{K}{\eta} - 1\right) \tag{1}$$

The storage time is related to the mirror losses and transmissions by

$$\tau_e = \left(\frac{l}{c}\right)\frac{1}{T+L} \tag{2}$$

so the loss inferred from the ringdown is

$$L_\tau = \frac{l}{c\tau_e} - T \tag{3}$$

and that from the the throughput measurement is

$$L_\eta = \frac{T}{2}\left(K/\eta - 1\right) \tag{4}$$

Using the measured parameters, the mirror loss L is computed in two ways:

Scattering + absorption per mirror

Measurement Method	Result
Ringdown, L_τ	210 ±60 ppm
Throughput, L_η	190 ±70 ppm

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[2]Obtained by taking the ratio of Equations 14 and 13 in *Contrast, Throughput, and Storage Time of Two-Mirror Cavities*, September 14, 1987.