INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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ADRIATICO CONFERENCE ON FOURIER OPTICS AND HOLOGRAPHY

6 - 9 March 1990

THE FOURIER OPTICS LABORATORY

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Outline

Environmental conditions:

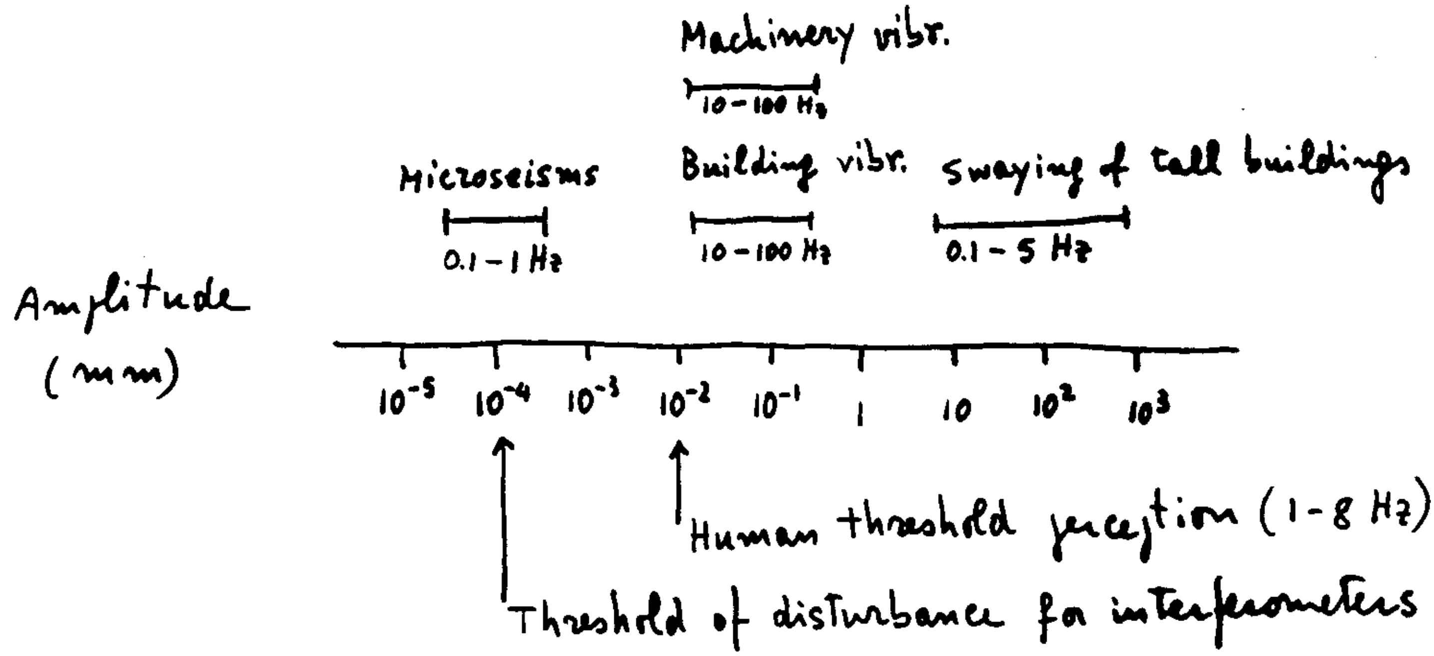
- Mechanical stability
- Thermal stability
- Humidity control
- Dust freedom & optics cleaning
- Safety

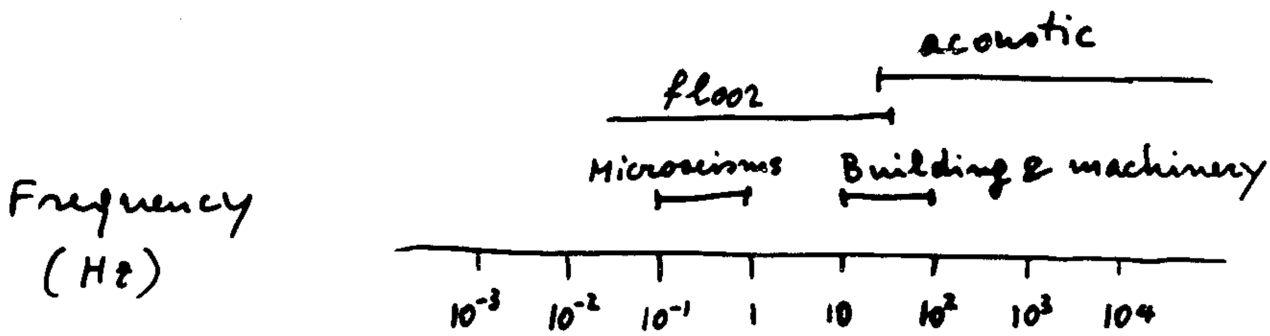
Off-the-shelf optical components and subsystems:

- Lenses
- Mirrors
- Beam splitters
- Spatial filter
- Beam expander
- Beam steering

Simple experiments

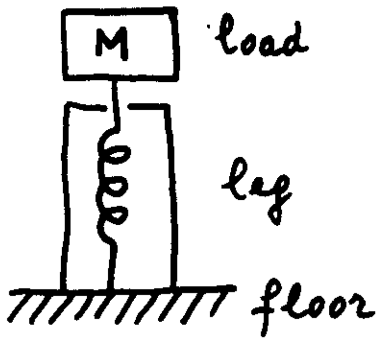
Environmental noise sources [after NRC catalog]





Major sources of instability:

1. Ground or floor vibrations
2. Airborne vibrations (acoustic)
3. Equipment induced vibrations
4. Quasi-static forces (load changes upon the system)
5. Thermal effects



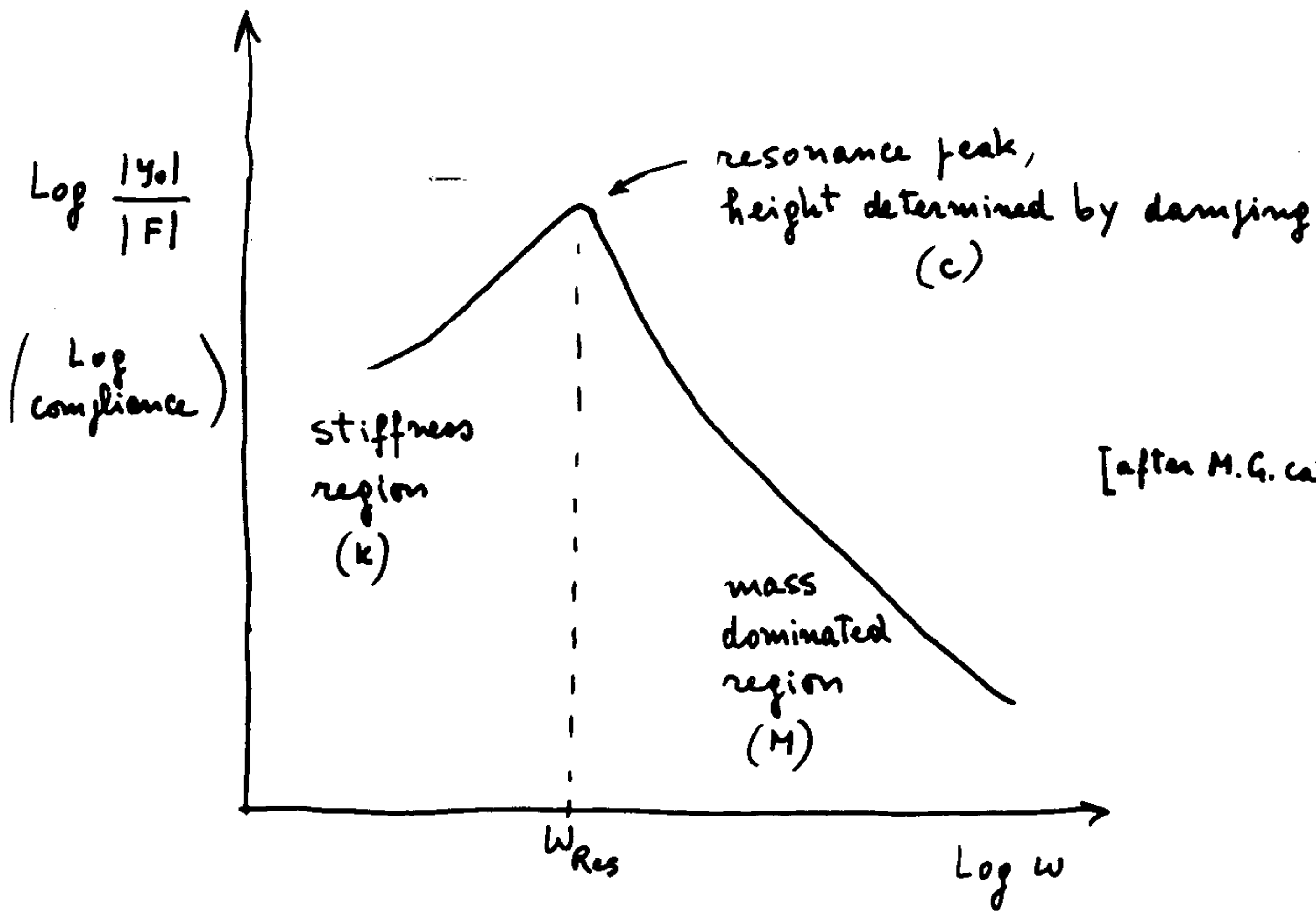
$$M\ddot{y} + c\dot{y} + ky = F \sin \omega t$$

- $c\dot{y}$: damping term
- ky: elastic force
- $F \sin \omega t$: driving force

$$\Longrightarrow \quad y = y_0 \sin(\omega t + \varphi)$$

$$y_0 = \frac{F}{\sqrt{(K - M\omega^2)^2 - (c\,\omega)^2}} \quad , \qquad \omega_{Res} = \sqrt{\frac{K}{M}}$$

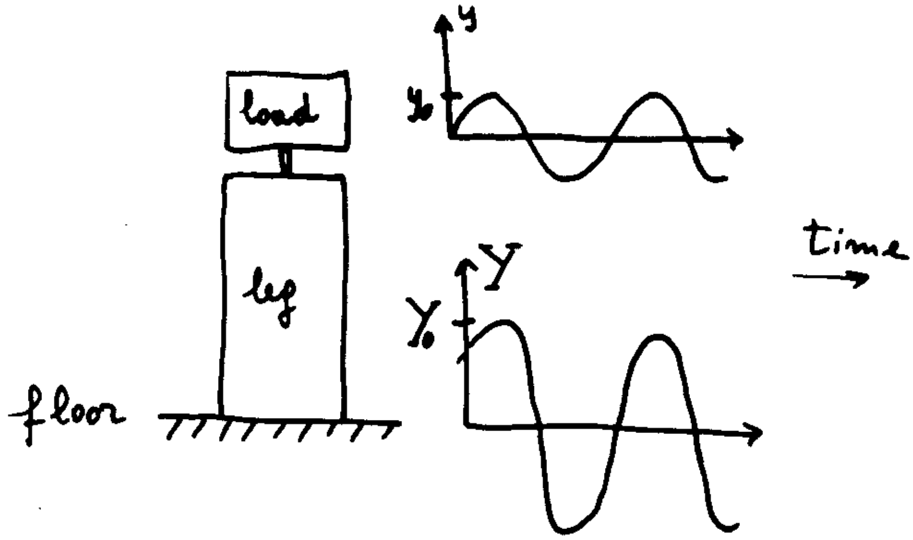
- K: stiffness
- $M\omega^2$: mass effect
- $(c\,\omega)^2$: damping

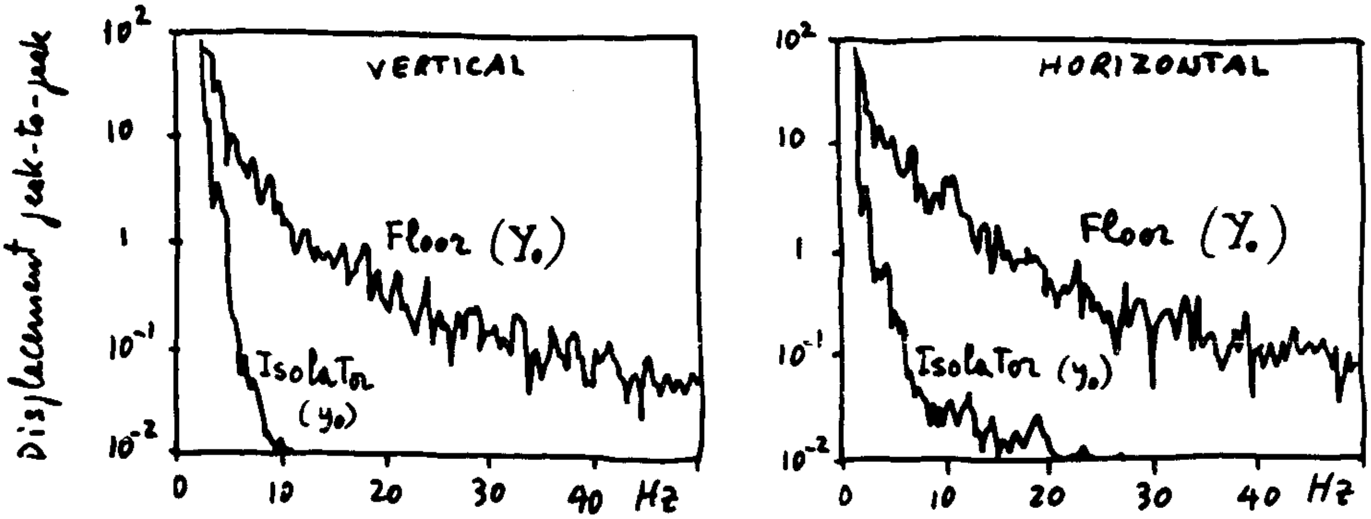


[after M.G. cat.]

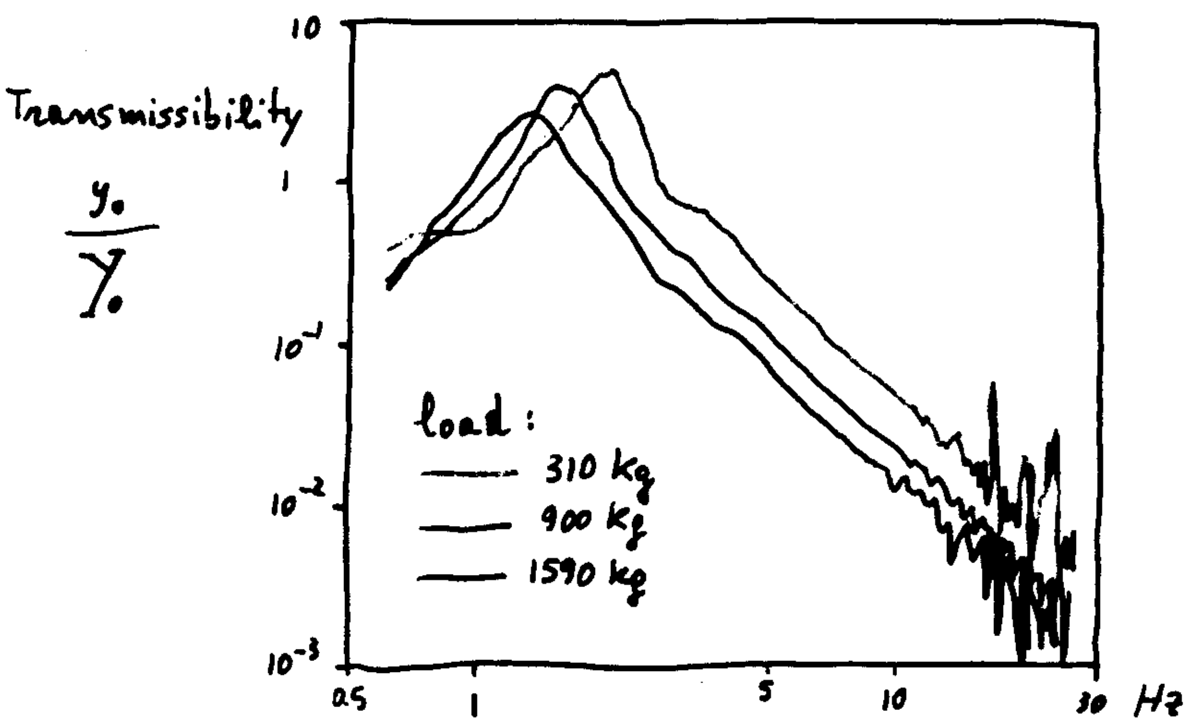
Load on isolation leg: Transmissibility curve

$$F \sin \omega t \propto Y_0 \sin(\omega t + \vartheta)$$





[after Ealing cat.]



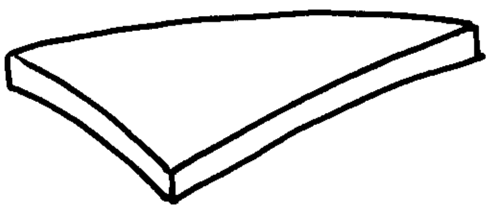
[after NRC]

... short axis bending is usually at higher frequency and thus less important.

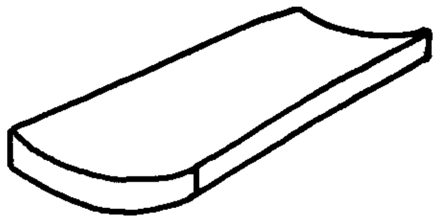
1st long bending mode

2nd long bending mode

[M.G.]

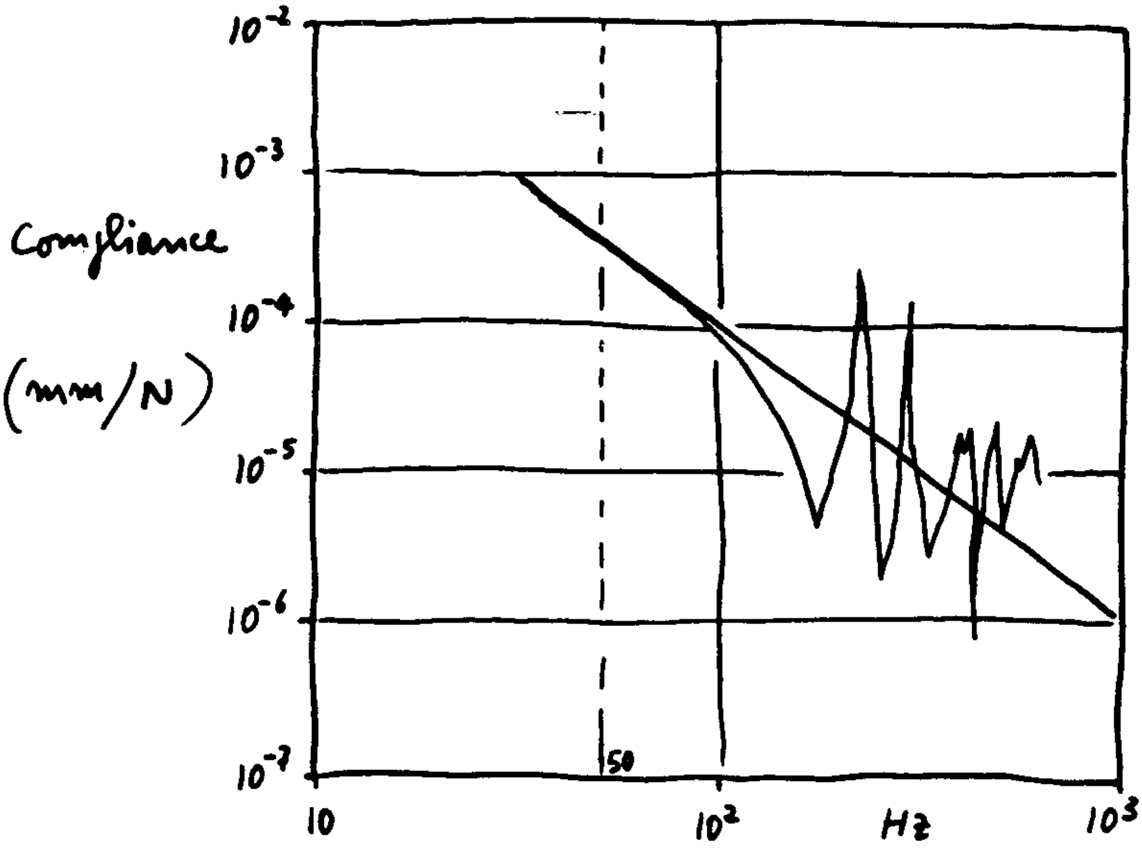


Torsional bending mode



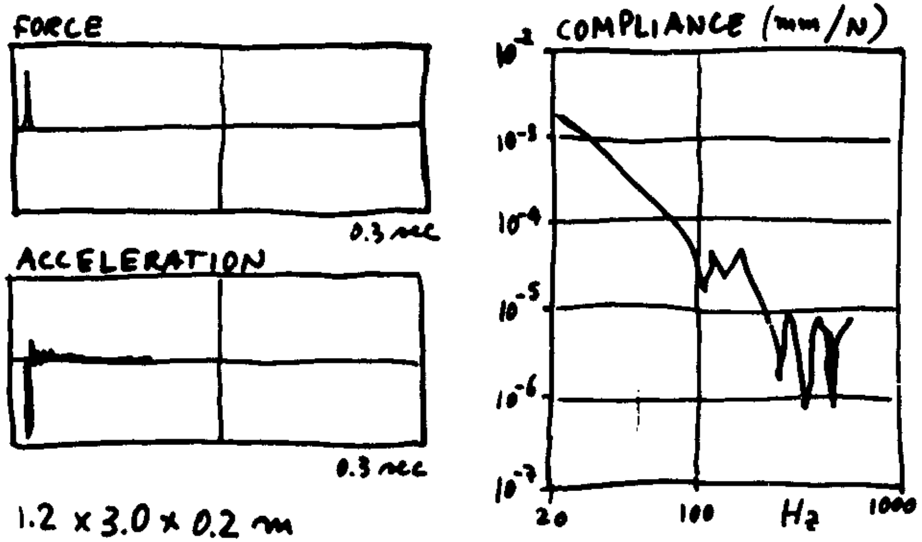
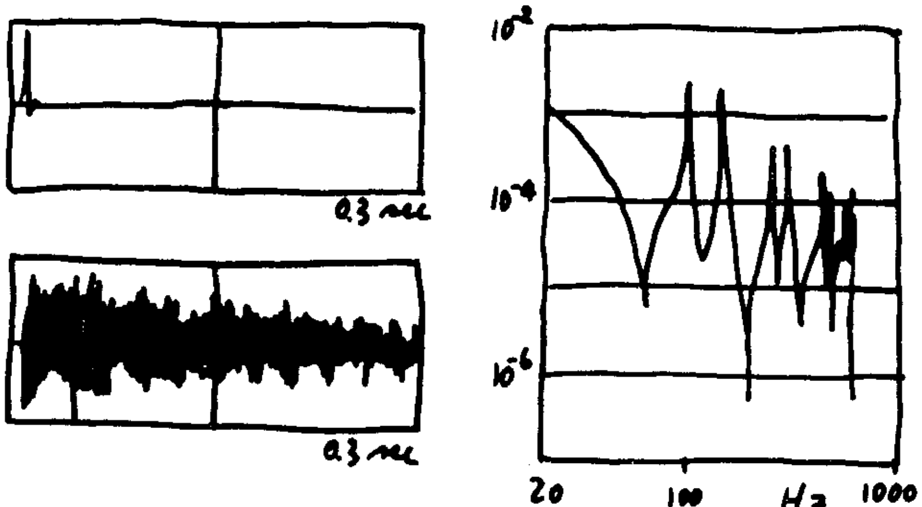
Short bending mode

Compliance curve for an aluminum honeycomb table, 1.2 × 1.8 × 0.2 m

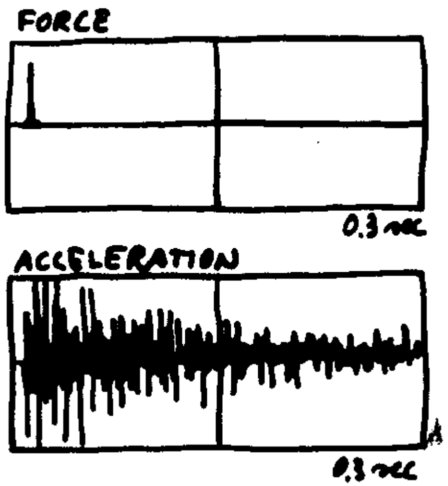


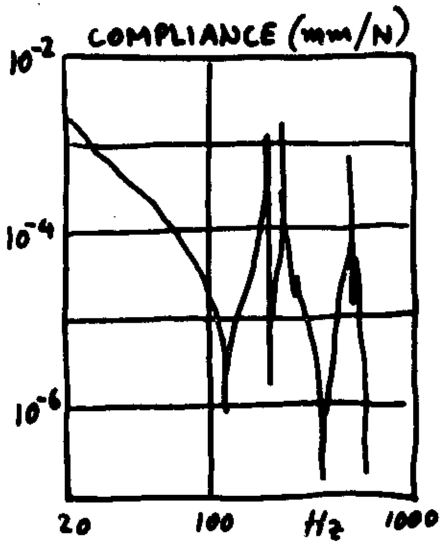
[NRC]

Comparison of Table Tops

Technique / construction	Advantages	Disadvantages
Typical damped honeycomb  1.2 x 3.0 x 0.2 m	- Excellent static and dynamic rigidity - Excellent long term stability - Can be fabricated in a wide range of sizes, shapes - Tapped holes for easy surface mounting - Convenient working surface (magnetic or nonmagnetic) - High stiffness to weight ratio	- Practical limit of flatness about ± 65 μ depending upon the si
Ordinary honeycomb panel  1.2 x 3.0 x 0.2 m	- High stiffness to weight ratio - Can be fabricated in a wide range of sizes, shapes - Convenient working surface	- Damping, static and dinamic rigidity are of more than 10x worse tha typical damped honeycomb - Honeycomb with viscoelas layers may have very poor long term stabilit due to creep - Practical limit of flatness

Granite (solid polished block)



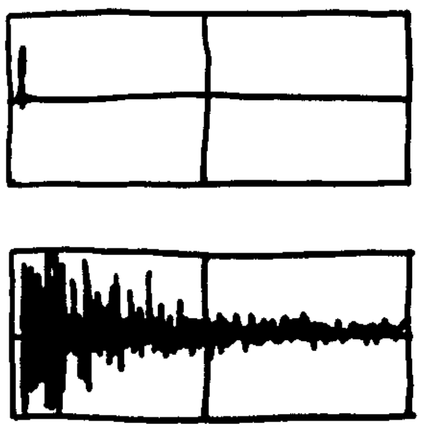


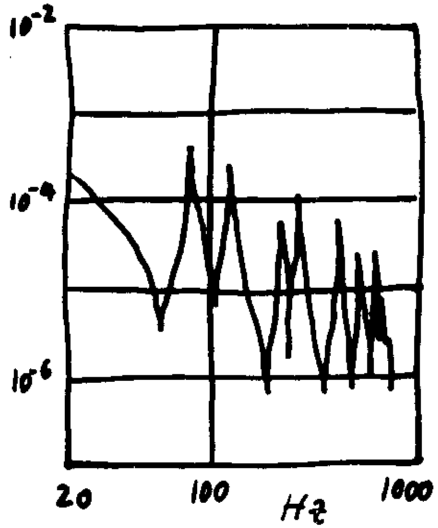
1.2 x 3.0 x 0.2 m

- Can be polished flat to a few microns depending on size
- Useful when flatness or mass is most important

- Difficult to mount components
- Low resonance frequencies
- May sag
- Difficult and expensive to tap
- working surfaces not magnetic
- Difficult to fabricate in special shapes
- Very heavy

Concrete (solid or reinforced block)



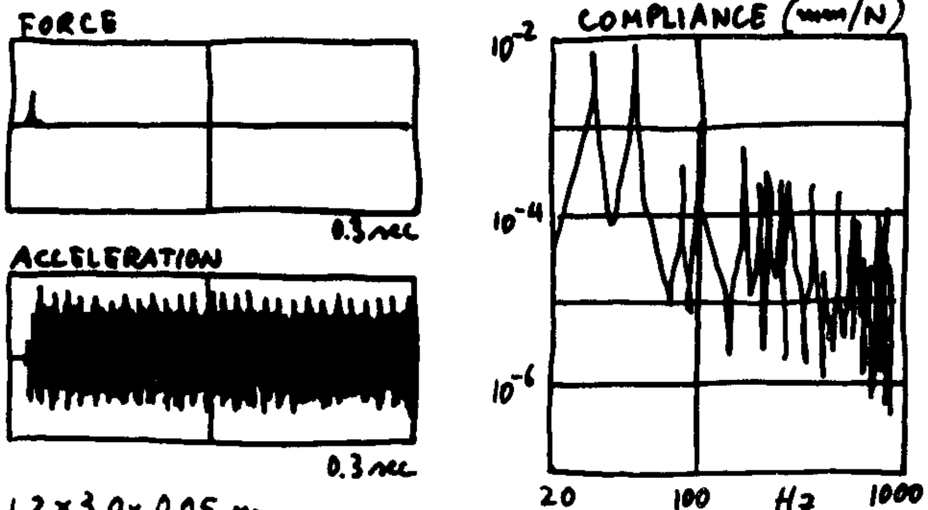


1.2 x 3.0 x 0.2 m

- Inexpensive
- Can be poured in situ for very large structures

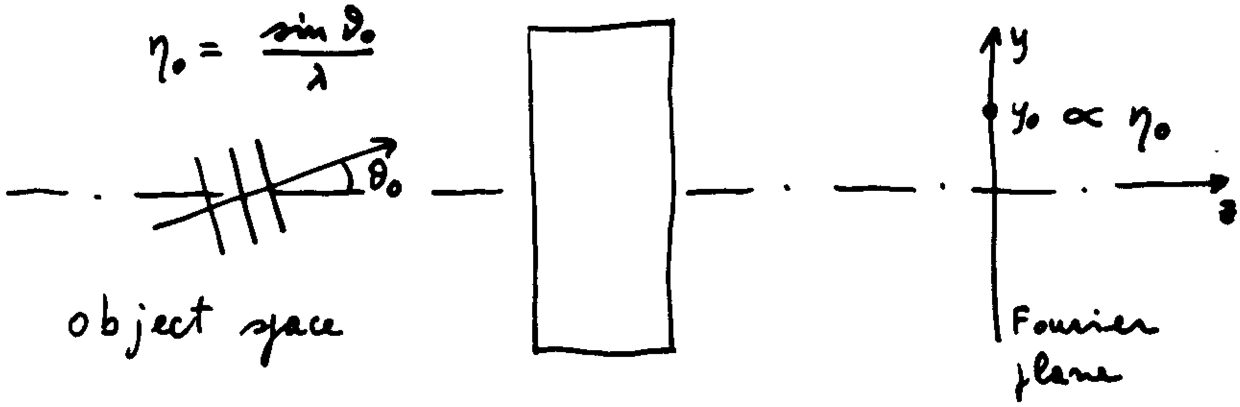
- Difficult to mount components to and has poor flatness
- Dirty chips flake off
- Can take up to one year to cure, causing poor stabili[ty]
- Size changes with hum[idity]
- Low resonant frequenci[es]
- Generally not recomm[ended] for vibration control, [but] useful as a heavy reactive mass

Cast iron, steel or aluminum plates or castings	- Inexpensive - Magnetic surface available - Can be machined	- Very poor dynamic rigidit - Low stiffness to weight ratio - Poor flatness

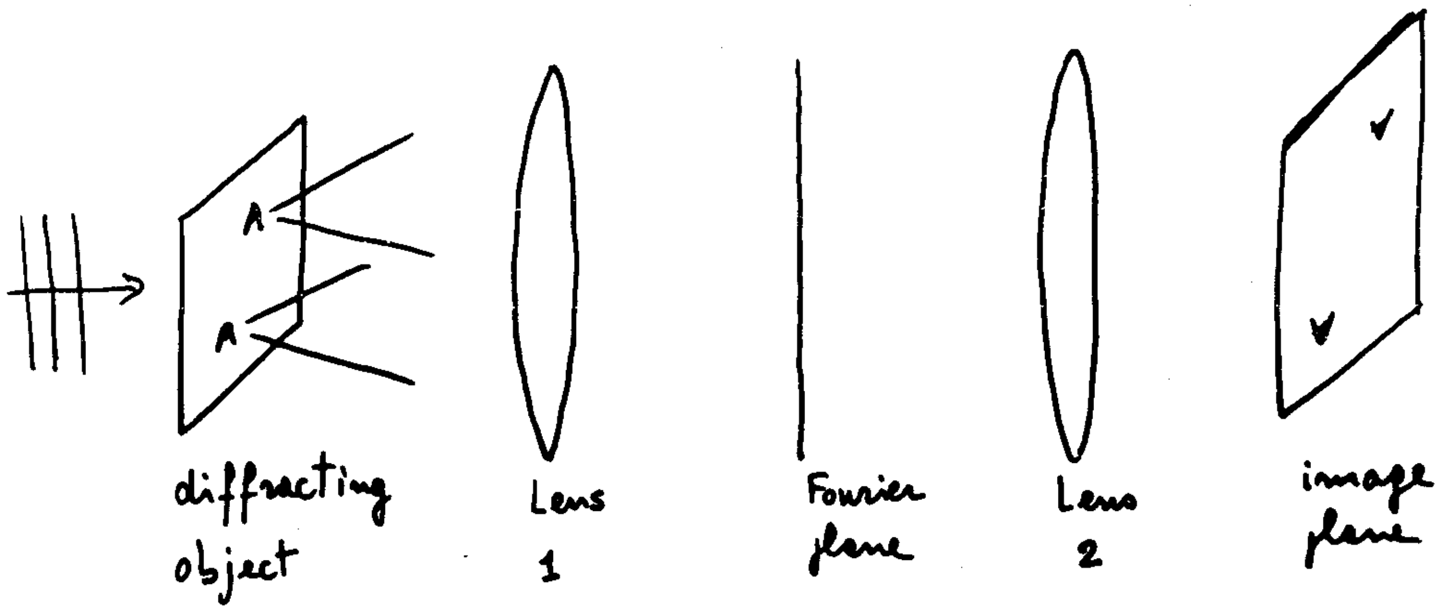


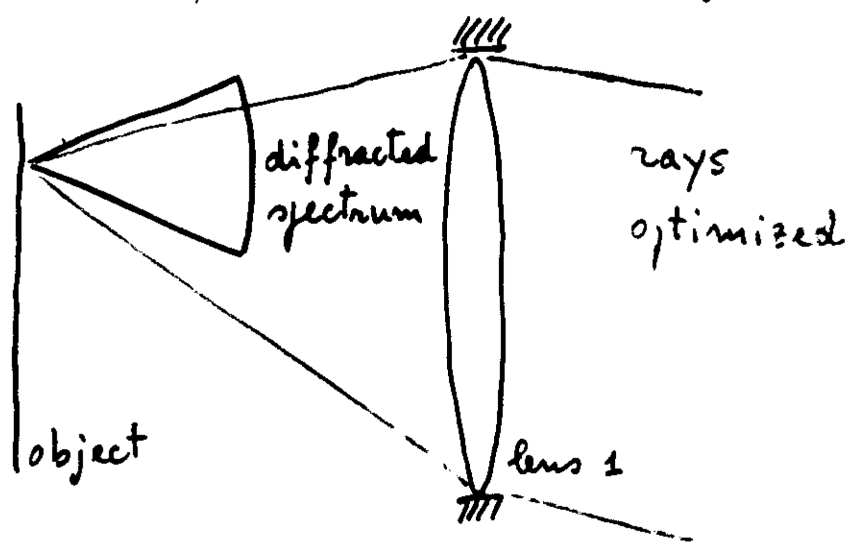
1.2 x 3.0 x 0.05 m

Eggcrate honeycomb (cells of vertical plates glued or welded between skins)	- Good static rigidity - Can be fabricated in special shapes	- Poorly damped - Poor local rigidity - Relatively heavy - Very low resonance frequencies - Very poor damping "ringing"
Marble (solid polished block)	- Good thermal conductor	- Sags and does not stay fle - Porous surface, stains - Difficult to fabricate in special shapes

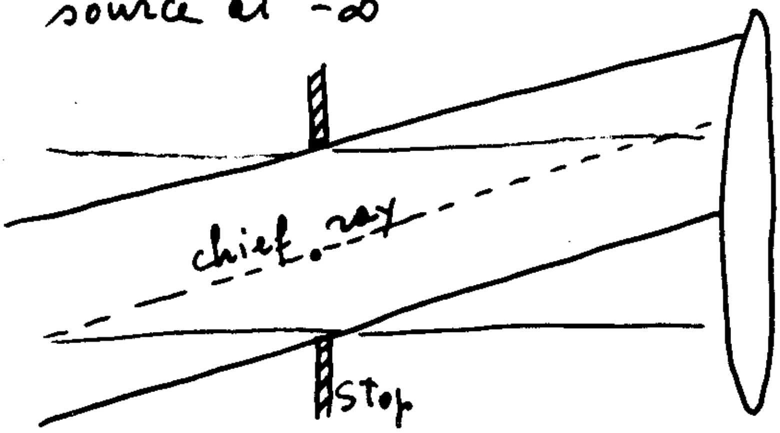


4-f processor: Geometrical optics approach

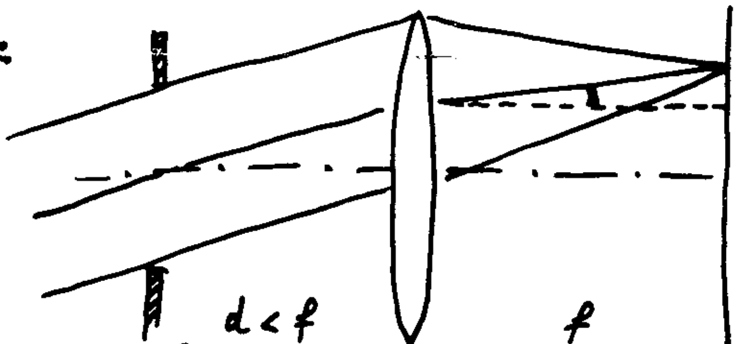




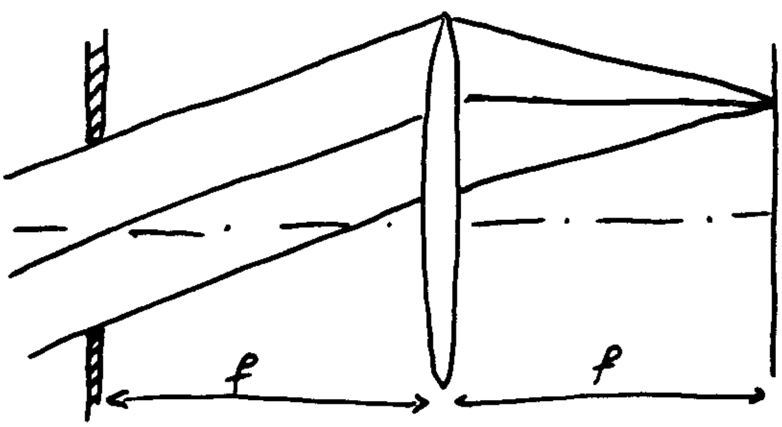
Stop at the object,
source at $-\infty$



Non-Telecentric
stop



Telecentric
stop

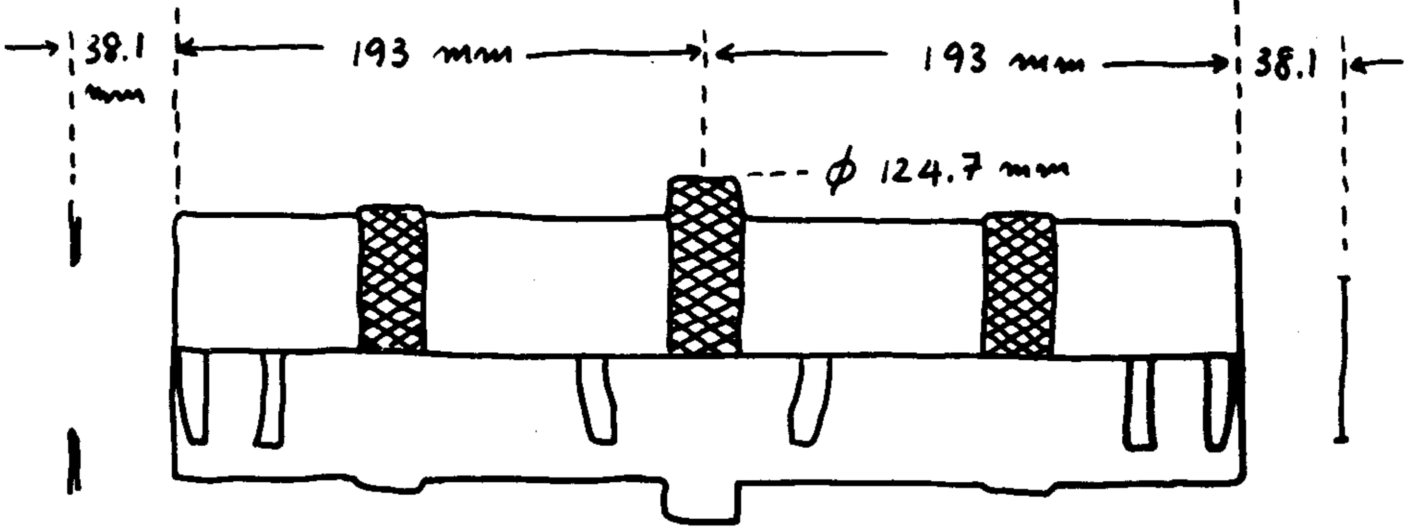


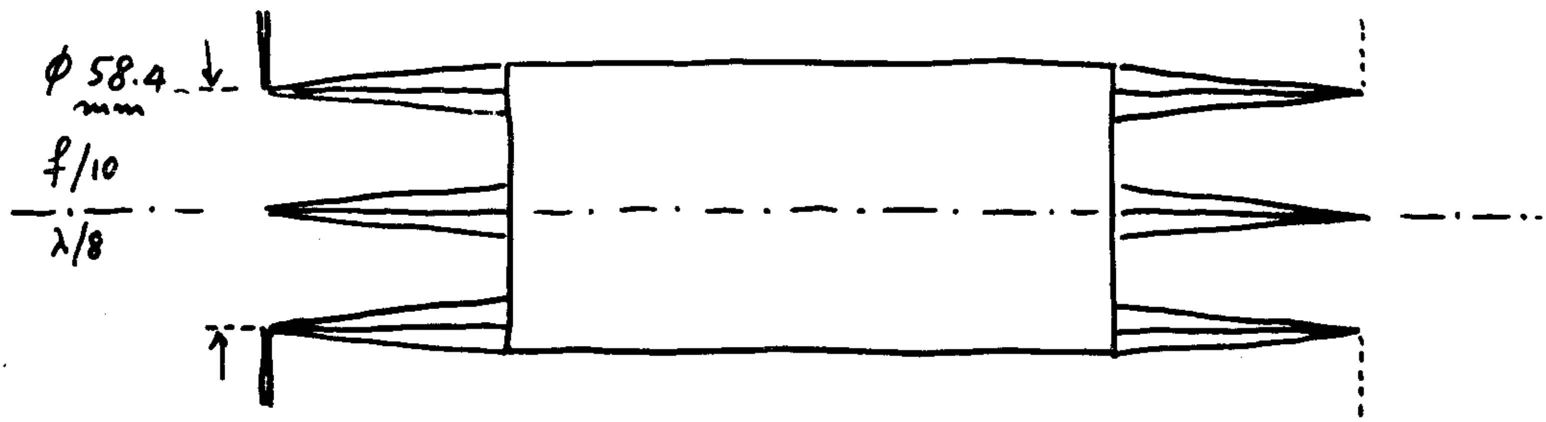
1. Stigmatic imaging at the back focal plane

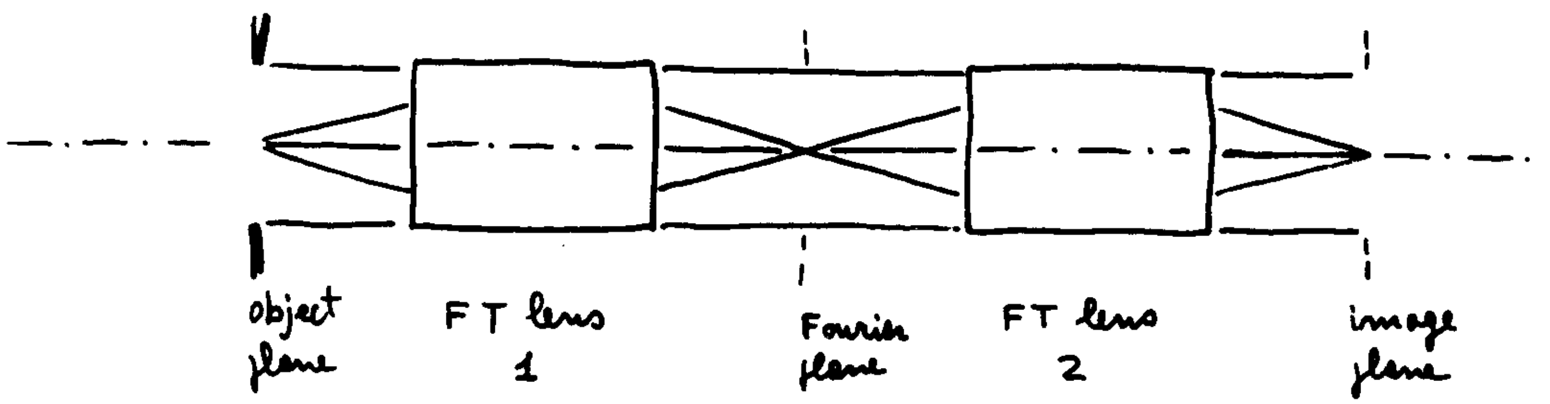
2. Chief ray fulfilling the sine condition $\eta \propto y$ ($\sin\theta \propto y$)

3. Telecentric stop, source at $-\infty$.

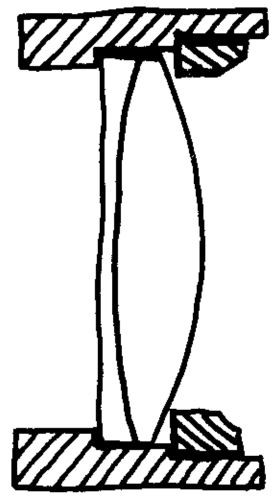
SYMMETRICAL FT LENS [TROPEL]

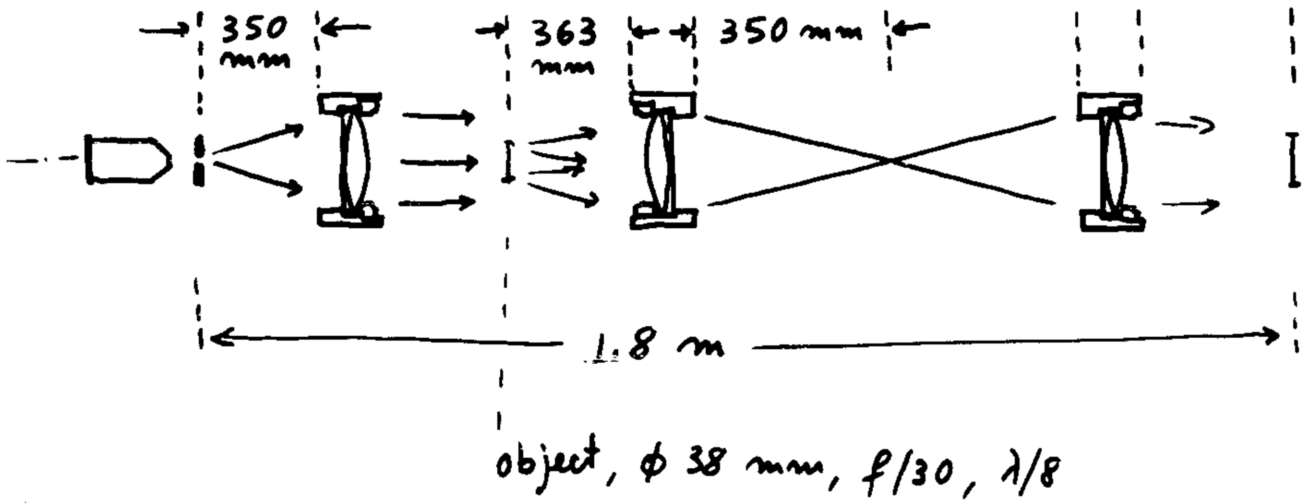






ACHROMATIC DOUBLET DESIGN [SOKL]





PLANO-CONVEX LENS

R1 = 50 mm

R2 = ∞

thickness = 5 mm

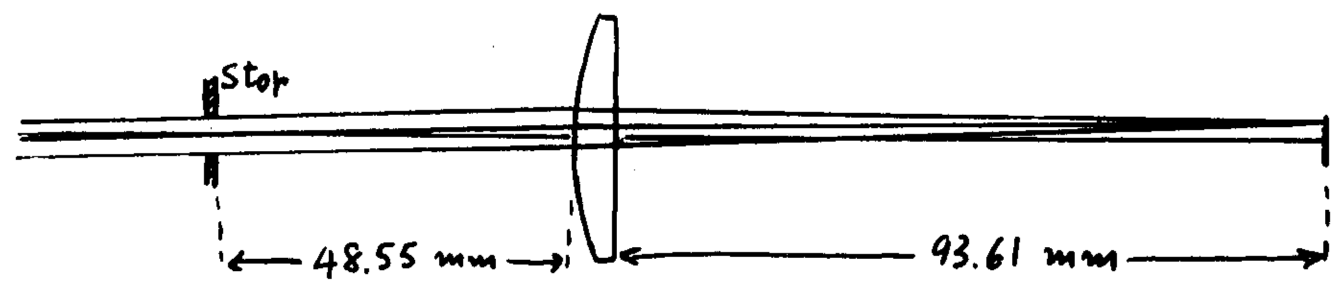
glass : BK7

λ = 633 nm

object ϕ 5 mm

f/19

$\lambda/8$



$\lambda/8$ operation at:

EPD	field angle	SW
5 mm (f/19)	1.6° (44 lp/mm)	220
10 mm (f/9.7)	0.5° (13.8 lp/mm)	138

Cube splitter: Aberration effects

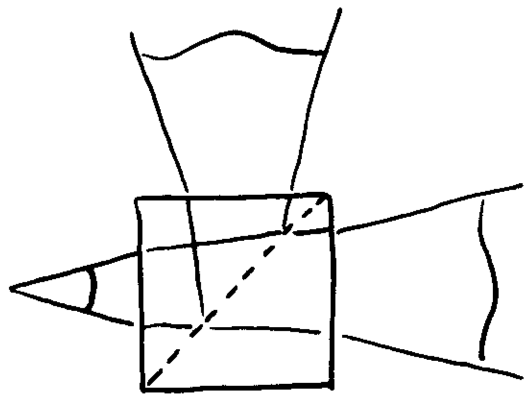
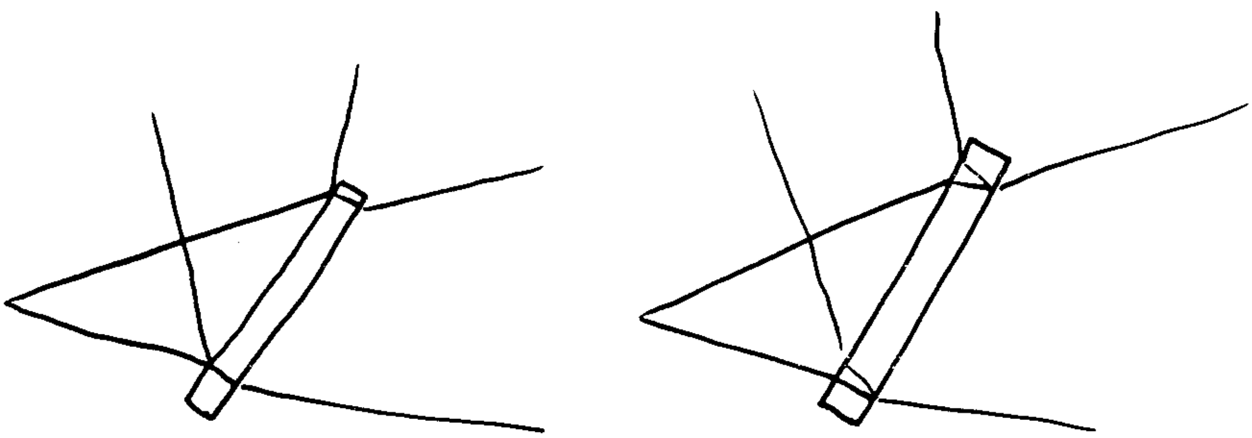
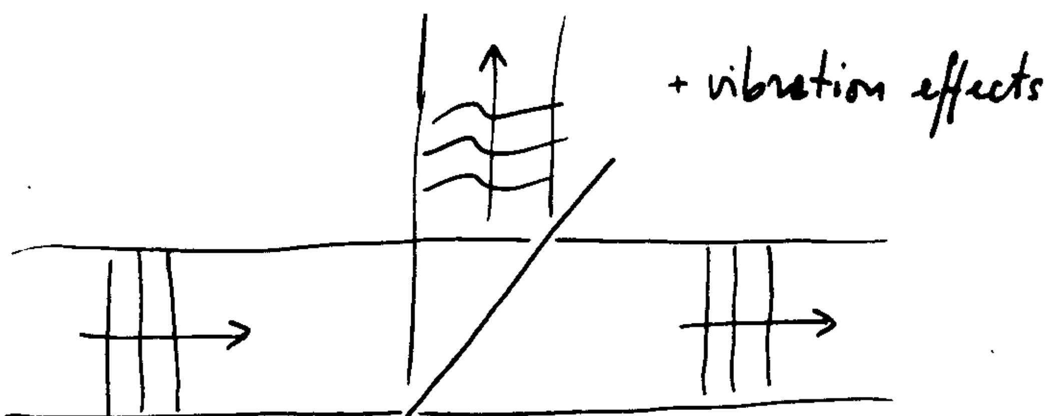
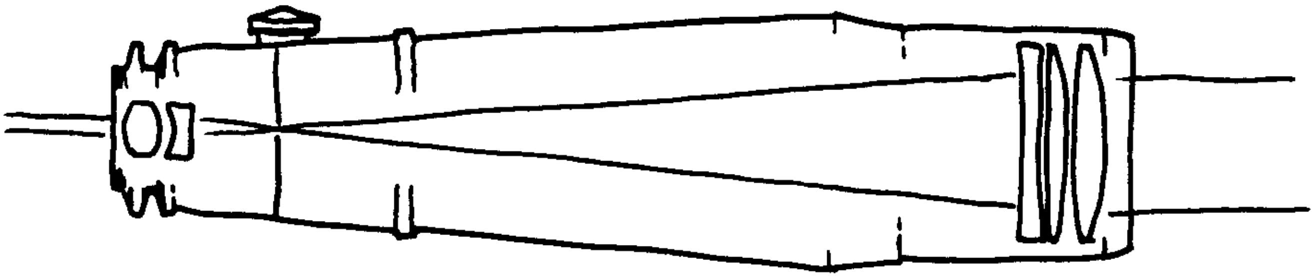


Plate splitter: Aberration effects

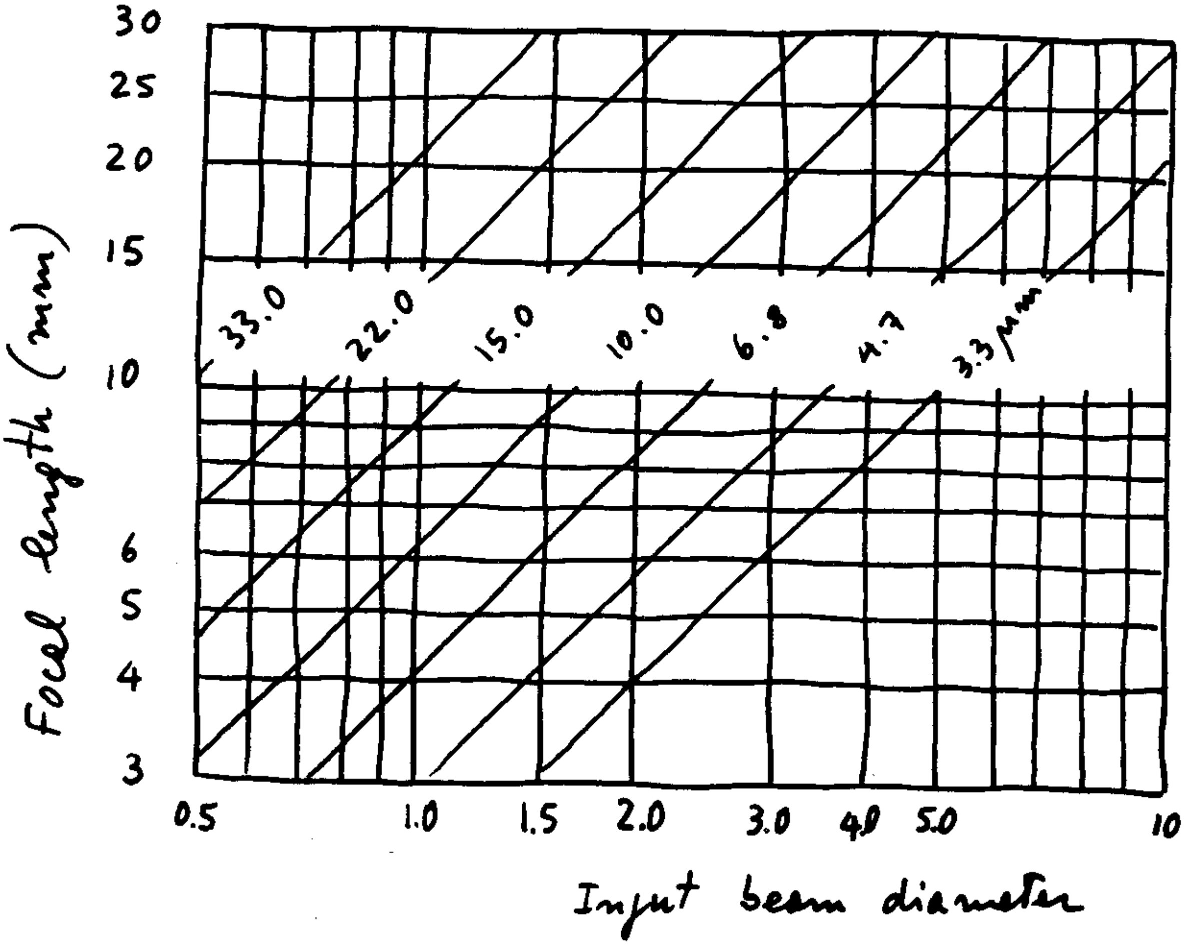


Pellicle splitter: Aberration effects

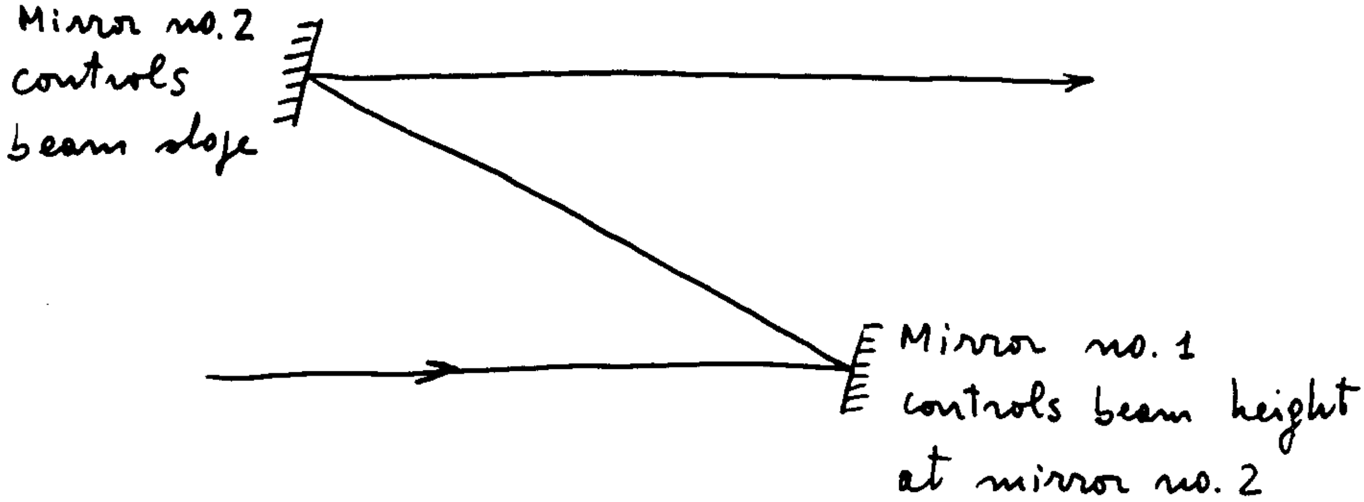




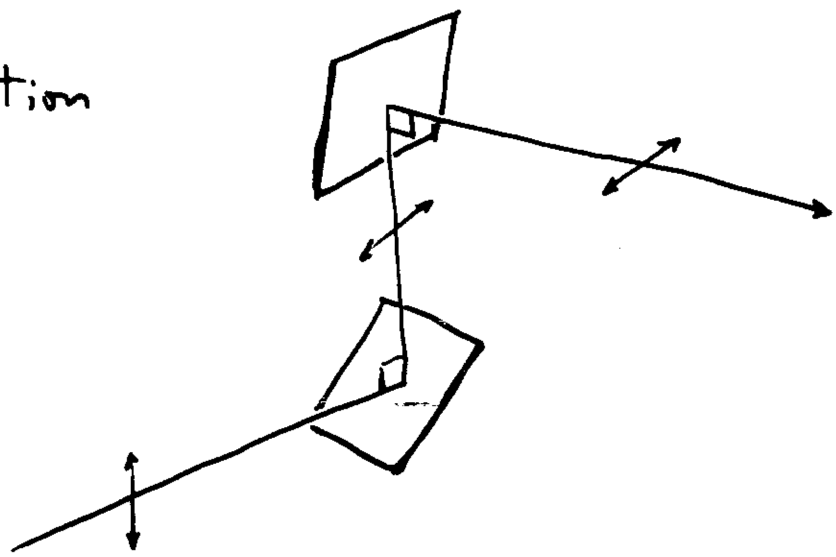
Choice of pinhole diameter



Beam Steering



Polarization effect



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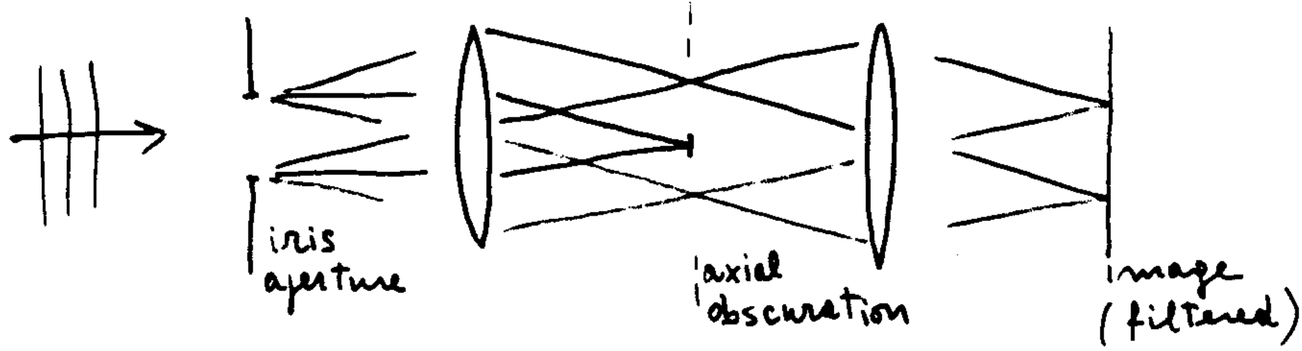
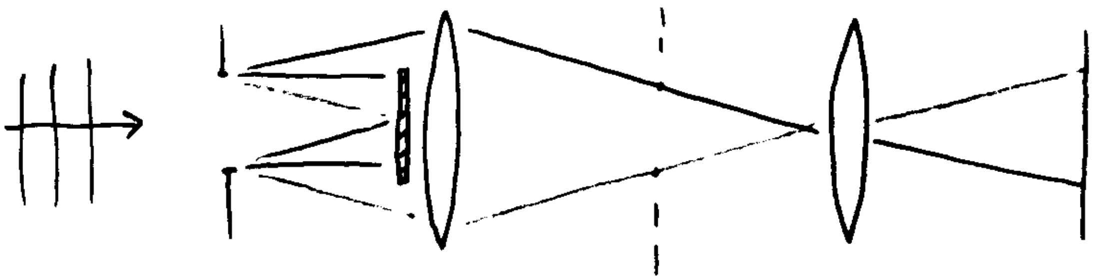
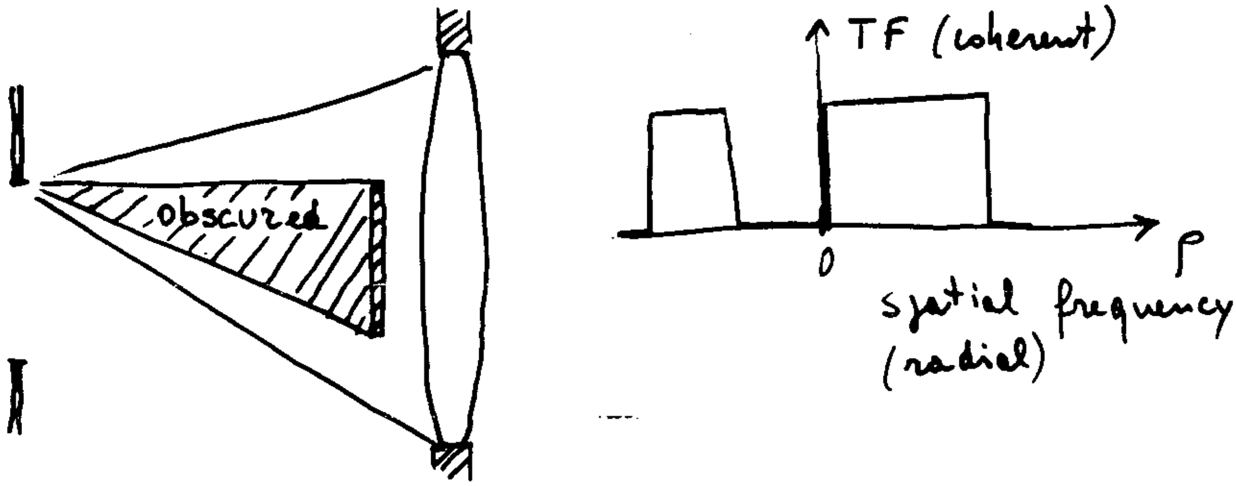
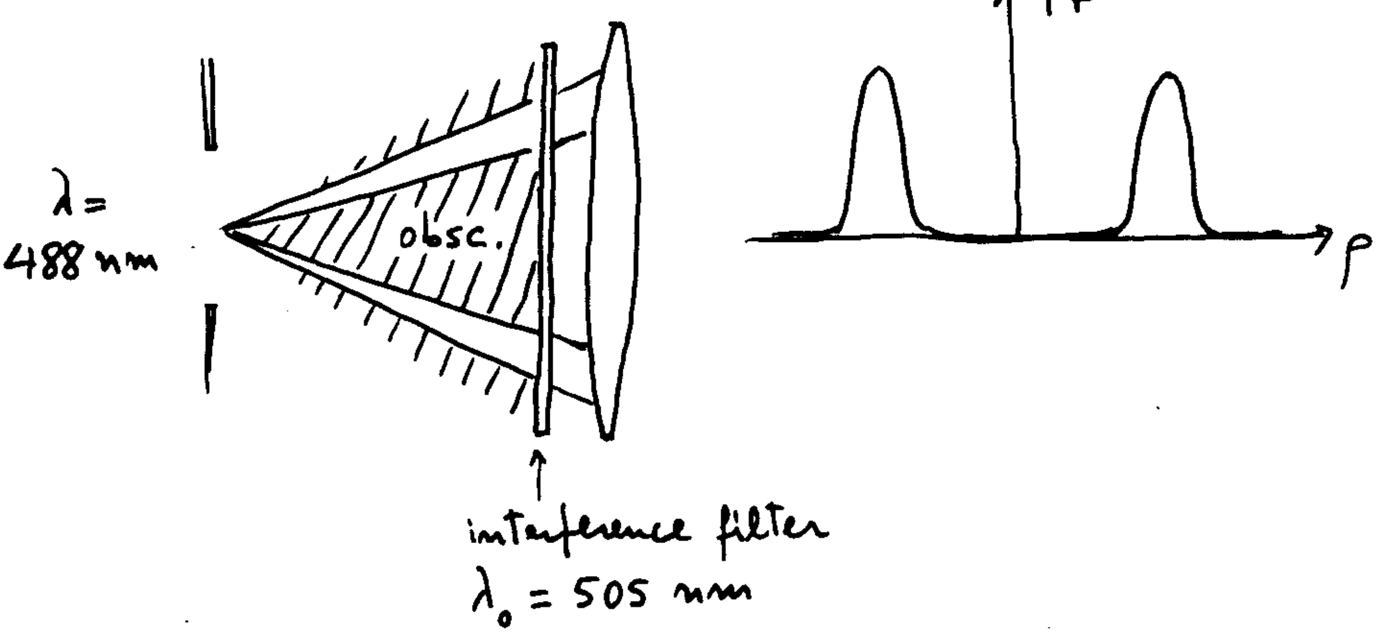
⋮


iris aperture
axial obscuration
image (filtered)




obscured
TF (coherent)
0
ρ
spatial frequency (radial)


λ = 488 nm
obsc.
interference filter
λ₀ = 505 nm
TF
ρ

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