Viewgraphs on Test Mass Suspensions and Suspension Noise

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TEST MASS SUSPENSIONS AND SUSPENSION NOISE

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THREE DIRECTIONS OF RESEARCH IN 1995:

1. STUDY OF DISSIPATION OF ENERGY IN PENDULUM MODES OF THE INTERMEDIATE MASS $M \approx 2$ KG, SUSPENDED BY FUSED SILICA FIBERS.
2. MEASUREMENT OF EXCESS NOISE IN TUNGSTEN WIRES
   i) EXCESS NOISE IN VIOLIN MODES,
   ii) TORSION JUMPS IN THE LOADED WIRES.
3. MEASUREMENT OF MAGNETIC FIELD AND ITS FLUCTUATIONS IN THE LABORATORY.

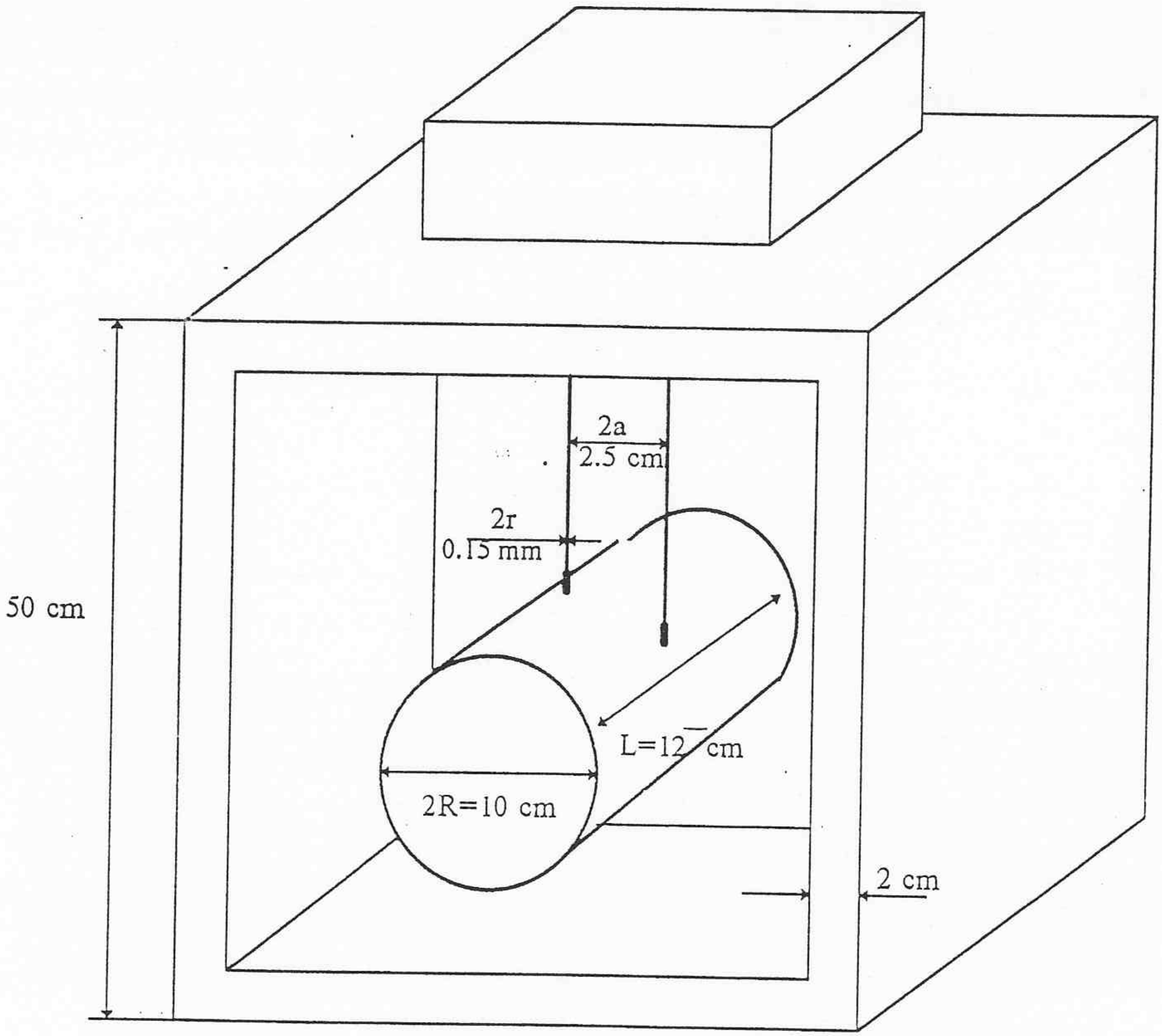


Fig. 1. Design of the double fiber pendulum and its support.

Q OF THE TORSIONAL-PENDULUM MODE OF THE TEST MASS SUSPENDED BY TWO FUSED SILICA FIBERS.

THIS MODE HAS SMALLER RECOIL LOSSES IN SUPPORT THAN THE ORDINARY PENDULUM MODE

$$f_{T\text{-}P} = 0.35 \text{ Hz}$$

TEORETICAL ESTIMATION OF THE LOSSES:

$$Q^{-1}_{MATERIAL} \approx \frac{\pi G r^4}{M g a^2}\phi_G + \frac{\sqrt{TYI}}{2MgL}\phi_Y < 3\cdot 10^{-9}$$

$$Q^{-1}_{\substack{SUPPORT \\ (SIMPLE\ MODEL)}} \approx \frac{J_{T.M.}}{J_{SUP}}\left(\frac{\omega_{T.M.}}{\omega_{SUP}}\right)^2 Q^{-1}_{OWN\ SUP} < 2\cdot 10^{-9}$$

THE MEASURED $Q = (0{,}5 \div 1)\cdot 10^8$.

POSSIBLE ADDITIONAL LOSSES MECHANISMS REQUIRED FURTHER DETAILE STUDY

a) CONTACT LOSSES IN THE SUPPORT STRUCTURE,

б) SILICA VAPOUR SEDIMENTS ON THE FIBER SURFACE,

c) ?!

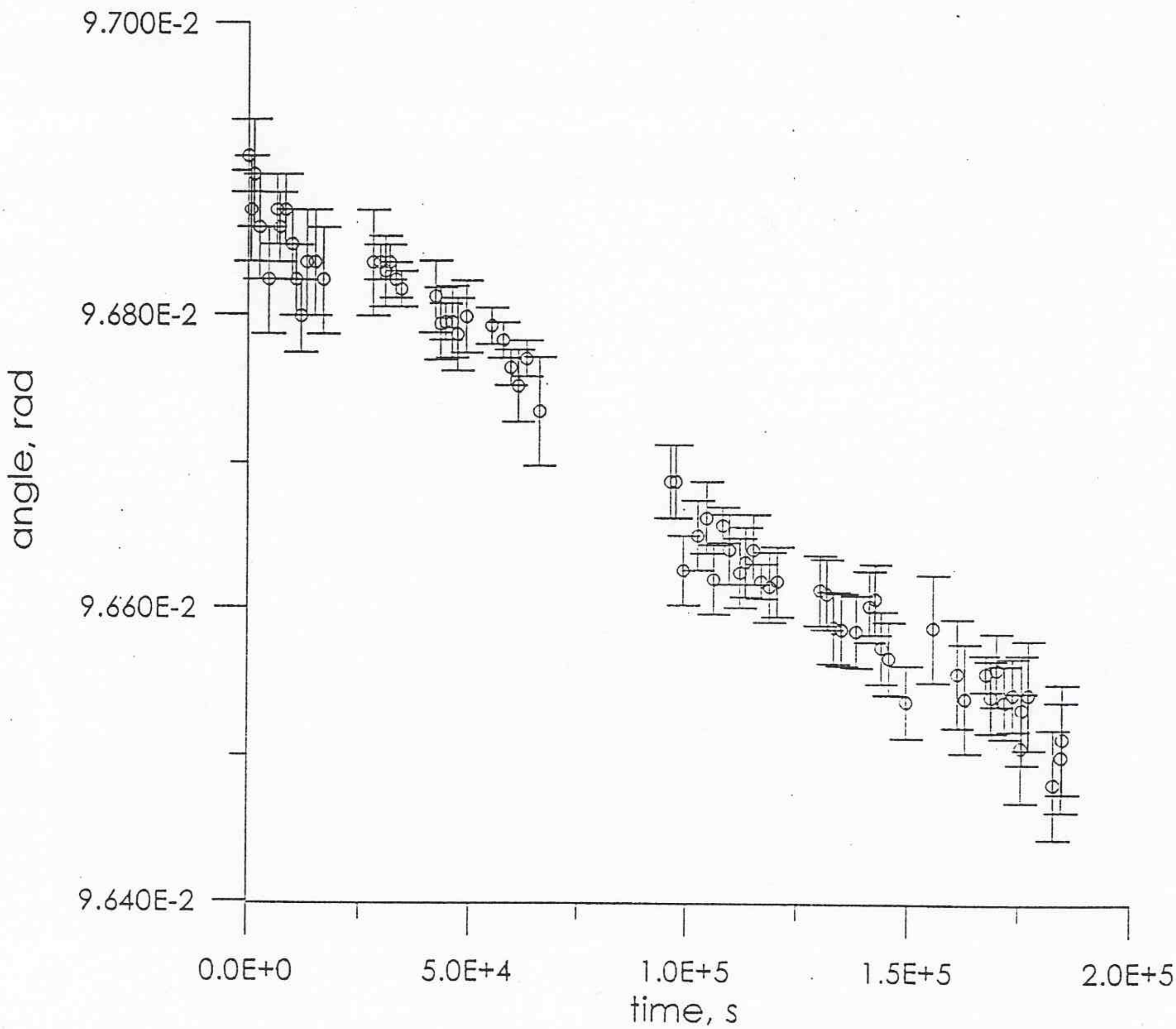


Fig. 2 . Time dependence of amplitude of the double fiber pendulum № 1
(M = 2 kg., d_{fiber} = 150-200 mkm, T=2.85 s).
The measured time of relaxation $\tau^* = 4.8 * 10^7$ s (±2 %).
With extraction of residual gas damping (p = $2 * 10^{-6}$ Torr)
$\tau^* = 1 * 10^8$s. (±25%)

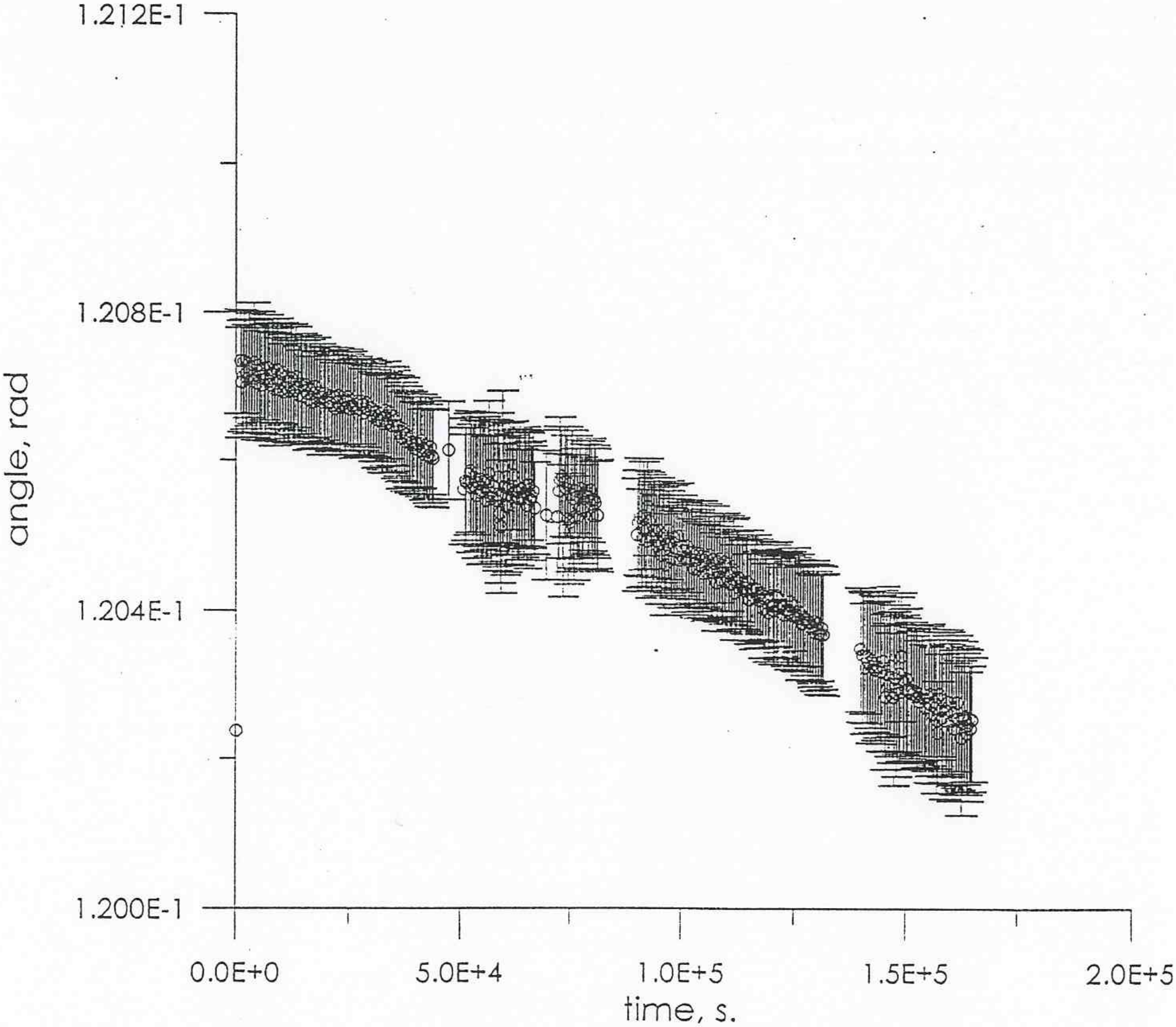


Fig. 3 . Time dependence of amplitude of the double fiber pendulum № 2
(M = 2 kg., d_{fiber} = 150-200 mkm, T=2.95 s).
The measured time of relaxation $\tau^*=4.6*10^7$ s ($\pm$2 %).
With extraction of residual gas damping (p = $1*10^{-6}$ Torr)
$\tau^*=6.5*10^7$ s. ($\pm$25%)

EXCESS NOISE IN THE VIOLIN MODES OF TUNGSTEN WIRES

$L_W = 15$ CM

$d_W = 20\ \mu M$

$\omega_W(\eta) < 2\pi \cdot 1.7$ KHz

$$\langle A \rangle_{THERM} = \frac{1}{\omega d}\sqrt{\frac{8 K_B T}{\pi \rho L}} \approx 8 \cdot 10^{-10}\ \text{CM}$$

RAYLEIGHT DISTRIBUTION OF AMPLITUDE

$\Delta f_{MEASUR} = 10$ Hz

$\Delta A_{RES} \approx 4 \cdot 10^{-11}$ CM

TIME OF OBSERVATION AFTER MOUNTING OF THE WIRE - 5 DAYS.

NET TIME OF MEASUREMENT - 3,5 HOURS.

THE FIRST RUN - $\eta \approx (0.4 \div 0.5)\, \eta_{BREAK}$

THE SECOND RUN - $\eta \approx (0.8 \div 0.9)\, \eta_{BREAK}$

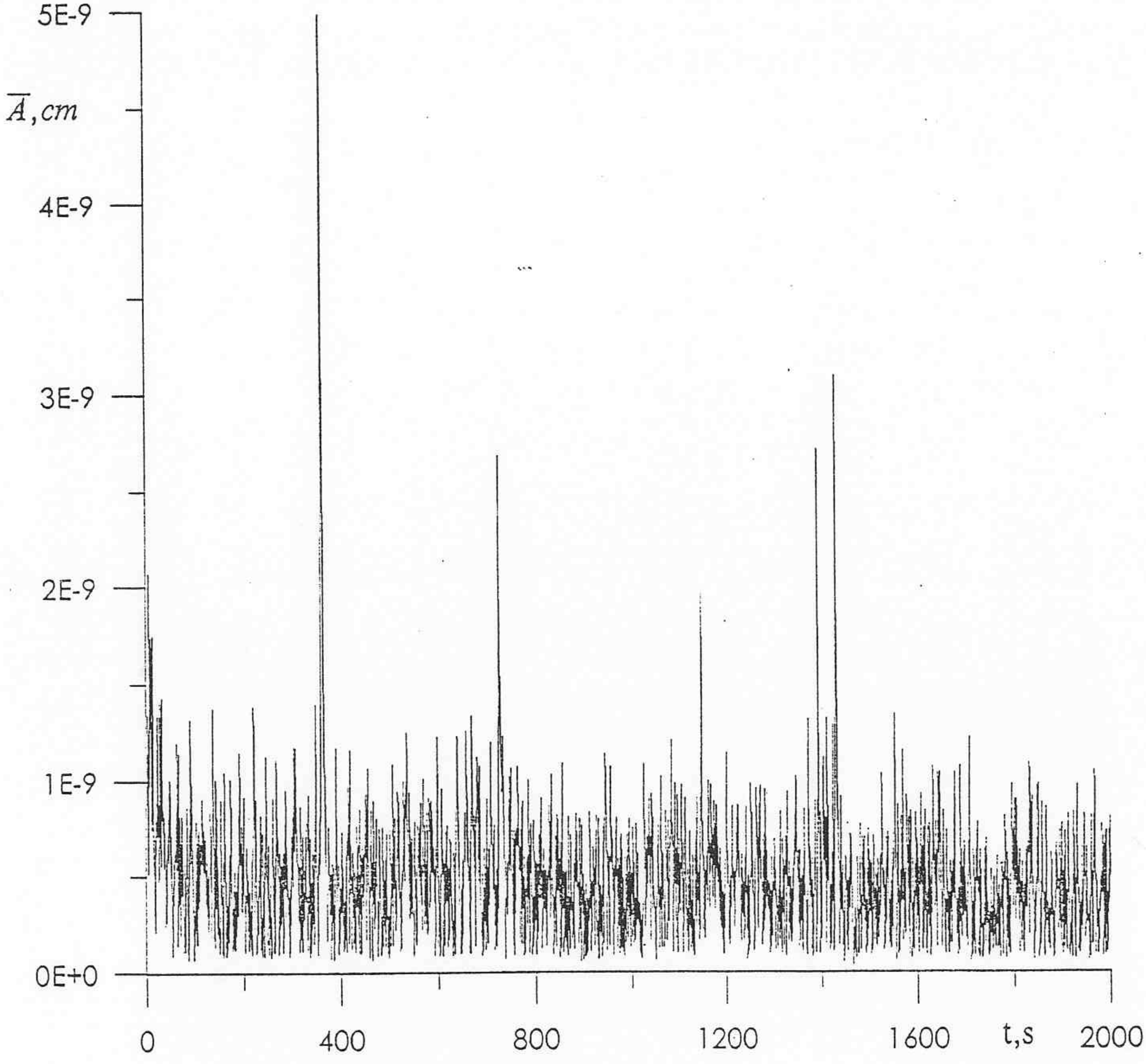


Fig. 5. Fragment of the record of noise oscillation of tungsten wire

TABLE 1

Number of amplitude peaks exceeded the given level

	Low stressed sample $\eta=0.5\eta_B$	Well stressed sample $\eta=0.9\eta_B$	Theory
>10 σ	0	298	<<1
> 9 σ	0	341	<<1
> 8 σ	4	427	0.19
> 7 σ	11	563	3.2
> 6 σ	38	800	38
> 5 σ	270	1478	320
> 4 σ	1748	3848	1900

DISTORTIONAL MECHANICAL EFFECTS IN THE WIRE SUSPENSION

THE CHANGE OF DEFORMATION IN THE WIRE DURING TIME PASSED AFTER LOADING

MICROPLASTICITY (FIG. 8) AND CREEP (FIG. 9) (η - STRESS IN THE WIRE)

MONOTONOUS DRIFT ROTATION OF THE WIRE (FIG. 10).

JUMPS OF THE ANGLE OF TORSION OF THE WIRE

$$\Delta\varphi \approx (5\cdot10^{-5} \div 3\cdot10^{-4})\ \text{RAD}$$

AT STRESSES $\eta \gtrsim 0.7\,\eta_{BREAK}$

THE MEAN RATE OF JUMPS $\sim 1\,(\text{HOUR})^{-1}$

POSSIBLE CONSEQUENCE: FOR $\Delta\varphi \simeq 10^{-6}$ RAD ($d = 10^{-2}$ CM)

THE CHANGE OF THE ANGLE OF THE TEST MASS $\sim 6\cdot10^{-14}$ RAD FOR 10^{-2} S.; IF THE LIGHT BEAM DISPLACEMENT $\Delta r \simeq 5\times10^{-3}$ CM, THEN $\Delta L \simeq 3\times10^{-16}$ CM

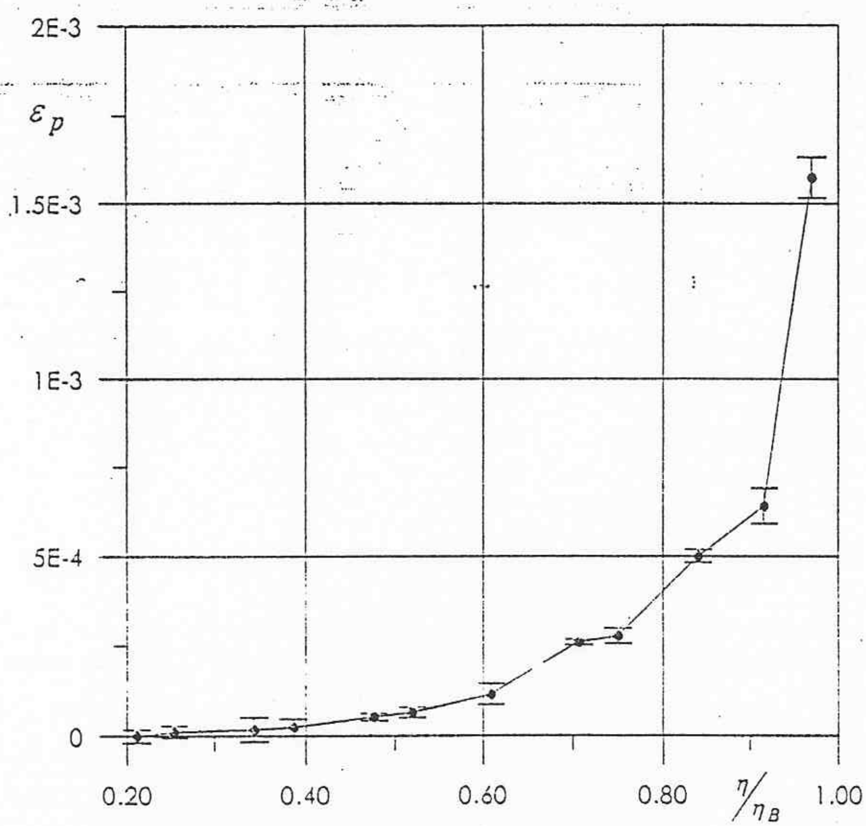


Fig.7 . Microplasticity of tungsten wire.

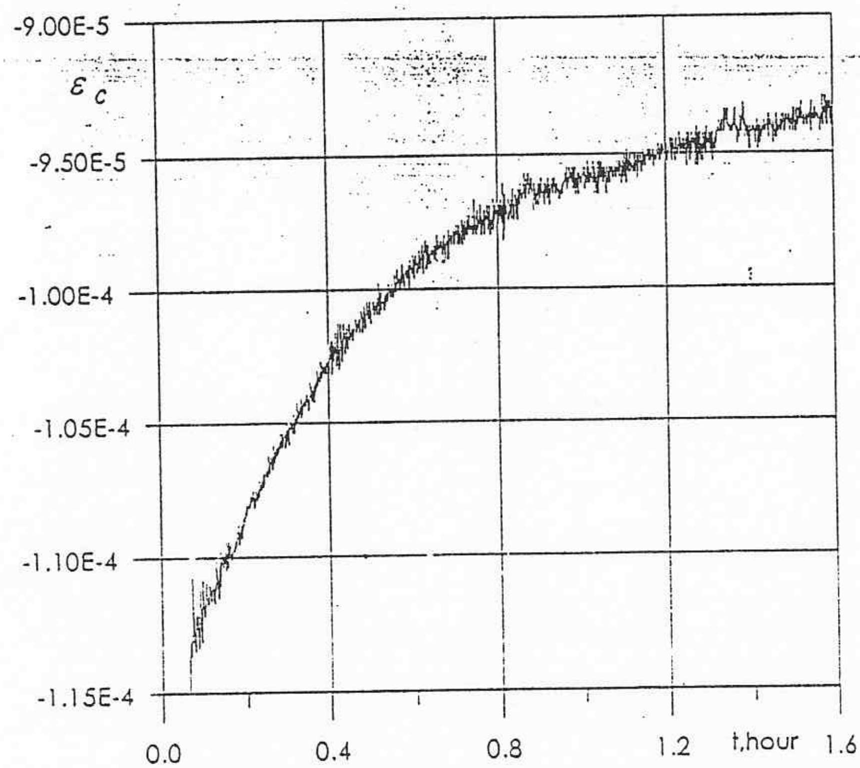


Fig. 8. Creep of tungsten wire (stress $\eta = 0.35\eta_B$).

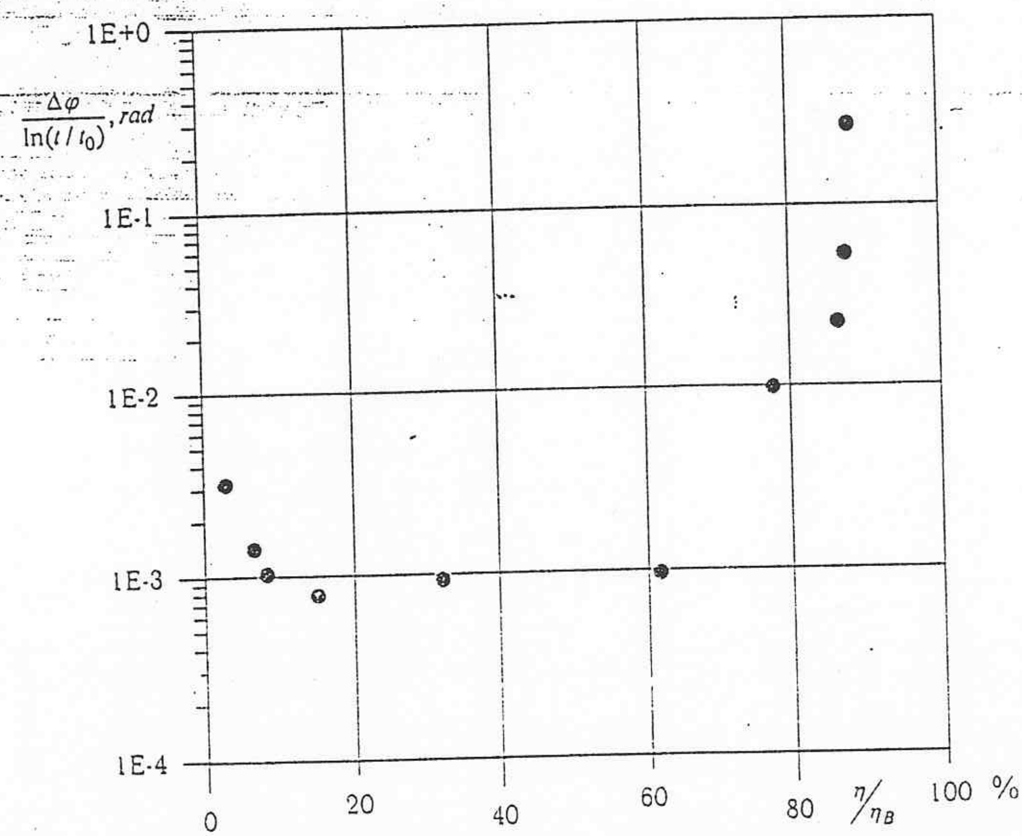
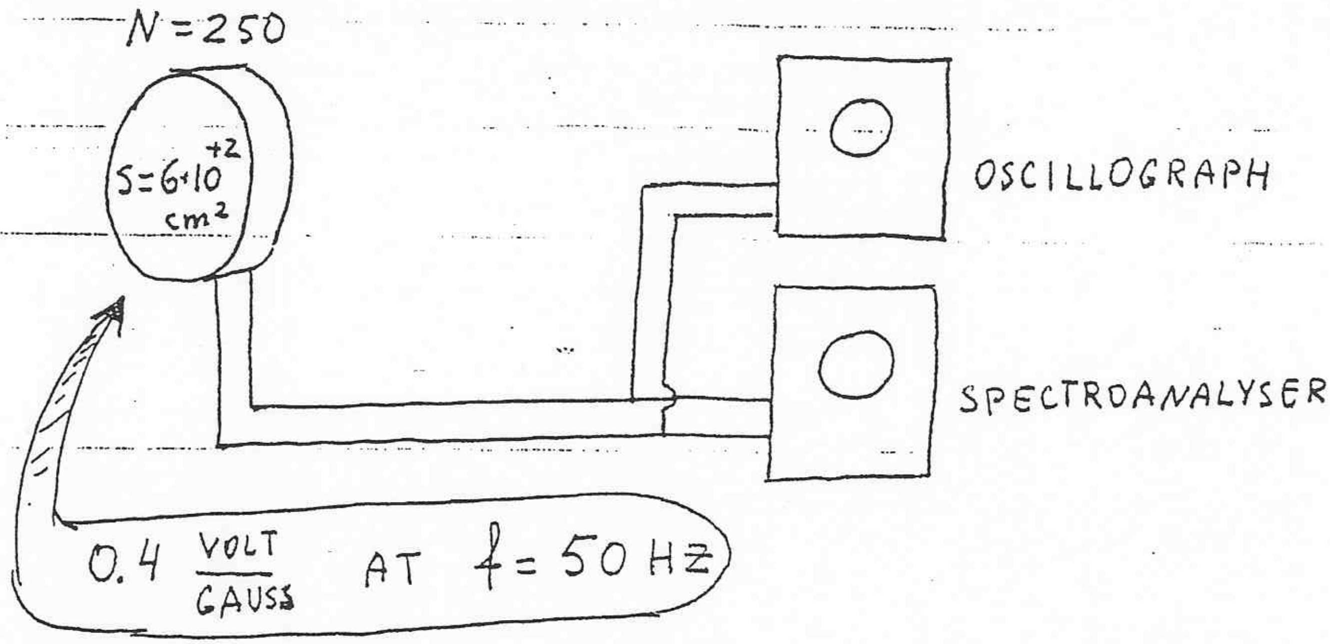


Fig. 9. Stress dependence of the angular drift rate of the wire.

THE FLUCTUATIONS AND THE CHANGES OF THE MAGNETIC FIELD IN THE LABORATORY



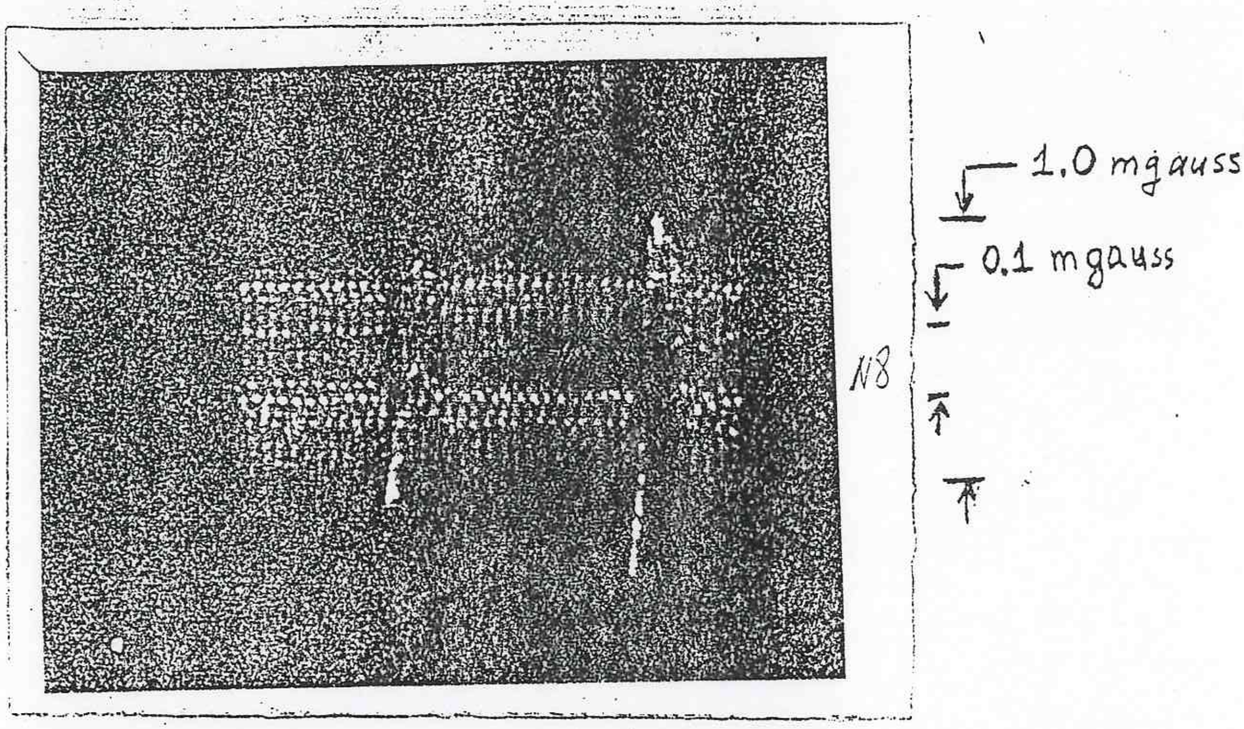
$$B_{PICK\text{-}TO\text{-}PICK} \simeq 3\times10^{-2} - 1\times10^{-4}\ GAUSS$$

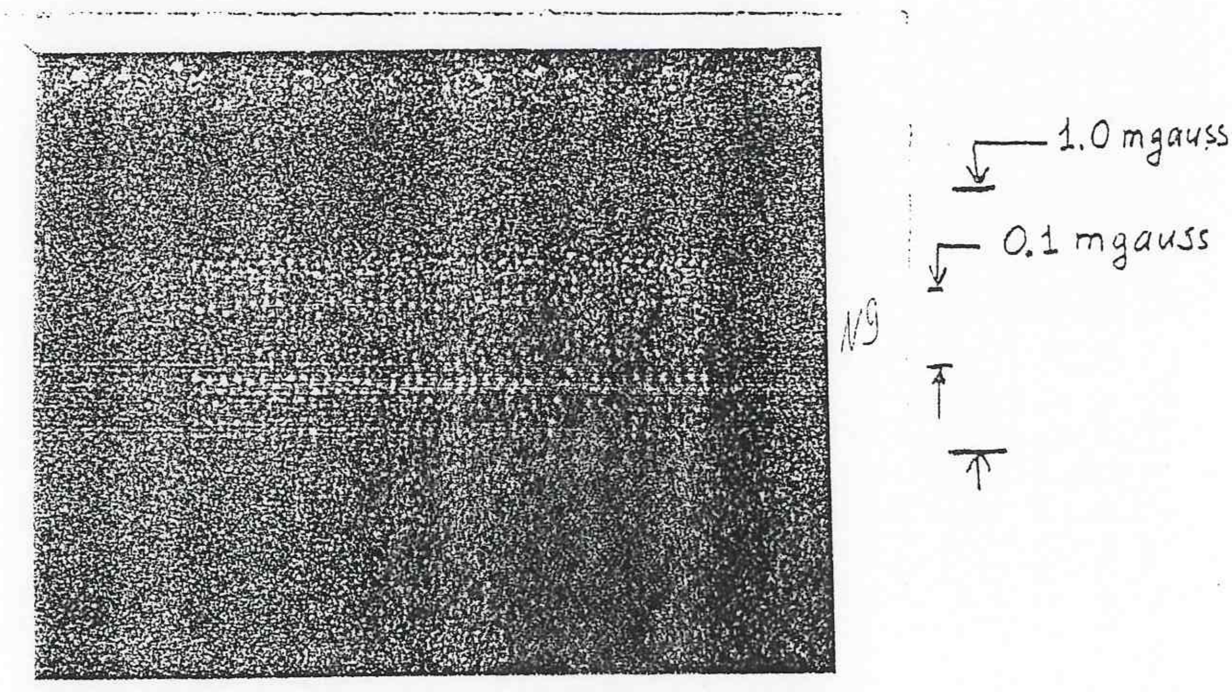
$$l_{CHARACHT} \simeq 50 - 100\ cm$$

$$\Delta B_{ON\text{-}OFF} \simeq (1-2)\times10^{-3}\ GAUSS \Rightarrow \begin{matrix}400\ WATT\\ 3\times10^{+2}\ cm\end{matrix}$$

$$\Delta B_{ON\text{-}OFF} \simeq 3\times10^{-4}\ GAUSS \Rightarrow \begin{matrix}100\ WATT\\ 3\times10^{+2}\ cm\end{matrix}$$

$$\Delta\tau \simeq 10^{-2}\ sec. - 10^{-3}\ sec$$


1.0 mgauss
0.1 mgauss
N8


1.0 mgauss
0.1 mgauss
N9

60 – 70 HZ $B_f \simeq 1\times10^{-6} \frac{\text{GAUSS}}{\sqrt{\text{HZ}}}$

80 – 90 HZ $B_f \simeq 4\times10^{-7} \frac{\text{GAUSS}}{\sqrt{\text{HZ}}}$

110 – 120 HZ $B_f \simeq 2\times10^{-7} \frac{\text{GAUSS}}{\sqrt{\text{HZ}}}$

$$\Delta X_f \simeq V_{\text{MAGN}} \times B_{\text{D.C.}} \times \frac{B_f}{\ell_{\text{CHAR}}} \times \frac{1}{m \times \omega^2}$$

V_{MAGN}: 3×10^{-2} cm^3 $B_{\text{D.C.}}$: 10^{+3} GAUSS m: $1.6\times10^{+3}$ GRAM

$$\Delta X_{65} \simeq 2\times10^{-15} \frac{\text{cm}}{\sqrt{\text{HZ}}}$$

$$\Delta X_{85} \simeq 5\times10^{-16} \frac{\text{cm}}{\sqrt{\text{HZ}}}$$

$$\Delta X_{115} \simeq 2\times10^{-16} \frac{\text{cm}}{\sqrt{\text{HZ}}}$$