Adolescent Years of Experimental Physics* (the childhood?)

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Vitaly L. Ginzburg: 30 major problems in physics (including Planck's values, dark matter, gravitational waves from astrophysical sources…)

Achievements (?) in previous 50 years

t	Δl (cm)	Δa (cm/sec^2)	$\Delta\omega/\omega$
$\lesssim$ 1950	10^{-12}		10^{-8}
$\simeq$ 1970	10^{-14}	10^{-8} (drag free satellite)	10^{-14}
today	10^{-16} (LIGO-I)	10^{-10} (-″-)	10^{-16}-10^{-17}

Promises (near future)

$\simeq$ 2010	10^{-17} (LIGO-II)	10^{-16} (LISA)	?

*Updated version of methodological notes published in *Physics-Uspekhi* 46(1) 81-87 (2003).

Evident Potential Possibilities (examples)

1) Reduction of wasted power:

$$\Delta L \simeq 10^{-16}\,\mathrm{cm}, \tau \simeq 10^{-2}\,\mathrm{sec}, (1-R) \simeq 10^{-6}$$

(available!)

Fabry-Perot resonat. $W \simeq 2\,\mathrm{erg/sec}$ -- possible!

but today (!) $W \simeq 10^{8}\,\mathrm{erg/sec}$ (LIGO-I)

2) Frequency stability: the prediction of quantum theory

$$\left(\frac{\Delta\omega}{\omega}\right)_{\mathrm{SQL}} = \sqrt{\frac{\hbar}{YV\tau}} \simeq 5\times 10^{-24} \quad \text{if } Y = 4\times 10^{12}\,\frac{\mathrm{erg}}{\mathrm{cm}^3},\ V = 10^{4}\,\mathrm{cm}^3,\ \tau = 10^{3}\,\mathrm{sec}.$$

Today existing methods of quantum measurements are underdeveloped ones:

- QND methods of measurements were successfully demonstrated in optical and microwave domains (including counts of microwave quanta without absorption) but still they are TOYS not TOOLS!
- e.g. One bit of information has to cost $\hbar/\tau$: experimentalists are not sufficiently inventive.

3) The achievements in near and in distant future in many experiments crucially depend on the culture "of ISOLATION of one or several" degree of freedom from heat bath (i.e. τ^*_m - relaxation time of a free mass, Q_{mech} and $Q_{e.m.}$ - quality factors of resonators)

EXAMPLES:

In LISA τ^*_m has to be $\simeq 10^{+3}$ years.

$$(Q_{\rm mech})_{SiO_2} \simeq 5\times 10^6\big|_{t\simeq 1980}\,;\ (Q_{\rm mech})_{SiO_2} \simeq 2\times 10^8\big|_{t\simeq 2004}$$

$$(Q_{\rm e.m.})_{Al_2O_3} \simeq 10^9\big|_{t\simeq 1987}\,;\ \text{prediction: } (Q_{\rm e.m.})_{Al_2O_3} \simeq 10^{16}$$

whispering gallery mode

if Al_2O_3 is pure enough.

G. Barton: Mechanical resonator in e.m. vacuum may have $Q_{mech} \simeq 10^{+60}$!

Experimentalists may and must realize many experiments with resolution many orders better than today's existing "culture" permits.