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Operation of prototype niobium gravitational radiation antenna
with microwave parametric accelerometer (*)

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Résumé. — Nous rendons compte de résultats expérimentaux qui confirment la possibilité d'utiliser un accéléromètre micro-onde associé à une antenne de radiation gravitationnelle en niobium à haut facteur de qualité, le tout soulevé par lévitation magnétique sans le moindre contact. On décrit le fonctionnement d'une antenne prototype.

Abstract. — We report experimental results which confirm the feasibility of using a magnetically levitated non-contacting microwave accelerometer in conjunction with a high Q levitated niobium gravitational radiation antenna. Operation of a prototype antenna is described.

1. **Introduction.** — As we have discussed elsewhere [1, 2] one approach to optimization of a GR antenna is to use Nb as an antenna material, exploiting its high acoustic Q , density, sound velocity, and its intrinsic superconducting properties. Magnetic levitation can provide near optimum vibration isolation and low loss suspension : antenna design therefore requires the bar diameter to be limited to that determined by the flux penetration field (Annealing : 10 hours at 1 900 °C, 10^{-9} torr). We have measured this in annealed and unannealed discs. Annealed samples, as expected, are inferior to unannealed samples, as shown in table I. Annealed bars however, can be levitated for diameters up to 0.21 m allowing levitation of a $3\text{ m} \times 0.21\text{ m}$ bar of mass 890 kg.

Table I.

	Flux penetration field	Maximum bar diameter
Annealed	0.19 T	0.21 m
Unannealed	0.25 T	0.37 m

Our Q -measurements show that annealing is essential to the attainment of high Q -values in Nb. We have observed a Q of 6×10^7 in a levitated annealed bar at 4.2 K, 10^{-2} torr, compared with 1.8×10^6 for a

similar but unannealed bar under the same conditions. The former value is limited by eddy current losses in the Al cradle between the levitation coils and the bar, caused by modulation of the levitation field by the bar vibration. This magnetic damping can be characterized by a magnetic Q -value, [3]

$$Q_m = KM\omega_0^{5/2}/B^2 A$$

where K is a geometric factor, B is the levitation field, A is the area of exposed normal metal, M is the bar mass and ω_0 its frequency. When this magnetic loss is removed by a NbTi shield to be described elsewhere [4] the Q -value should be raised to its intrinsic value which we estimate as 1.1×10^8 .

The attainment of magnetic levitation and high Q makes a massive Nb antenna appear attractive, as long as it can be operated without degradation by the associated readout device. A prototype system which achieves this is now described.

2. **Prototype antenna.** — The prototype GR antenna is illustrated in figure 1. A $0.3\text{ m} \times 50\text{ mm}$ Nb bar, is levitated on the field of two elongated pancake coils. The accelerometer has the form of a cylinder 8 cm diameter and 12 cm long, covered in NbTi sheet, and levitated on another pair of elongated pancake coils. Pancake coils A and B provide chassis-bar and bar-accelerometer repulsion and drive coil C provides forces independent of displacement to compress the magnetic springs due to coils A and B.

(*) This paper was presented at the LT 15 Conference as a post-deadline paper.

orders of magnitude improvement are expected when the accelerometer is operated in a vibration-isolated system with a $0.1 \text{ m} \times 1 \text{ m}$ antenna. Further developments nearing completion include a SQUID coupled to the energising transformer to improve the damping, frequency stabilization with a Nb cavity to

reduce phase noise in the microwave signal, and low noise parametric amplification of the re-entrant cavity signal.

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References

- [1] RAND, R. E. and BLAIR, D. G., *Aust. Phys.* **14** (1977) 131.
 - [2] BLAIR, D. G., MILLS, J., RAND, R. E., *IEEE Trans. Mag. MAG* **13** (1976) 350.
 - [3] SMYTHE, W. R., *Stat. & Dyn. Elect.*, 3rd ed. (McGraw Hill, N. Y.) 1978, p. 371.
 - [4] FERREIRINHO, J., BLAIR, D. G., *Applications of Flux Trapping*, to be published.
 - [5] MANN, A. G. and BLAIR, D. G., *Levitation Monitor*, to be published.
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