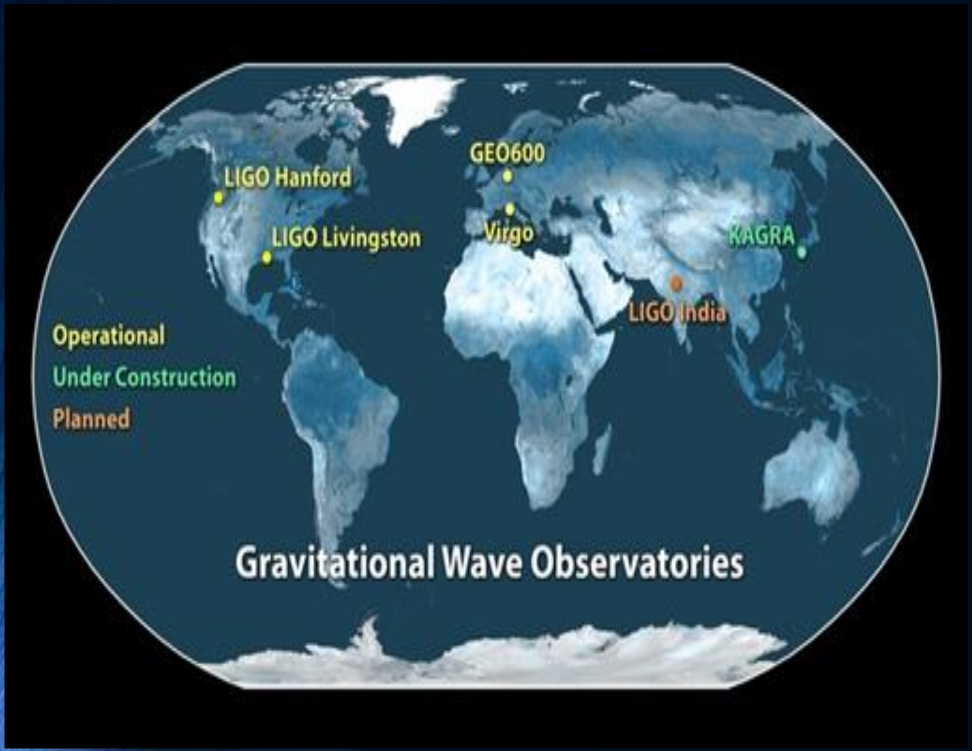
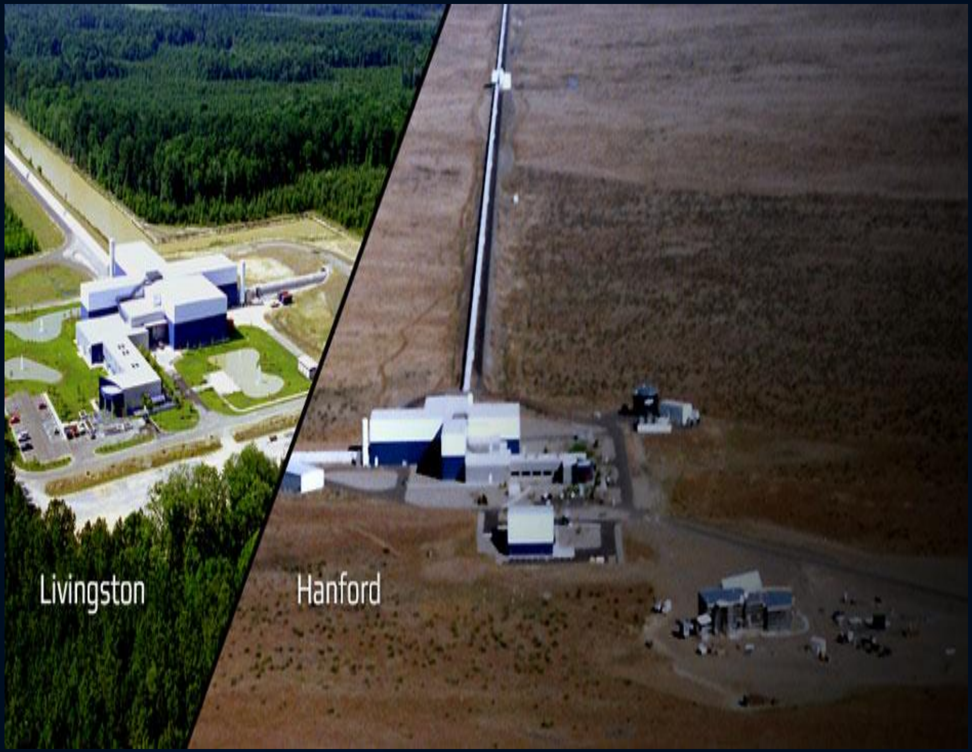
An experiment to measure the speed of gravity: optimization of the rotating quadrupole mass

Carlos Frajuca, Marco Antonio da Souza,
Daniel Coppede, Fabio da Silva Bortoli,
Givanildo Alves dos Santos and Francisco Yastami Nakamoto

Sao Paulo Federal Institute

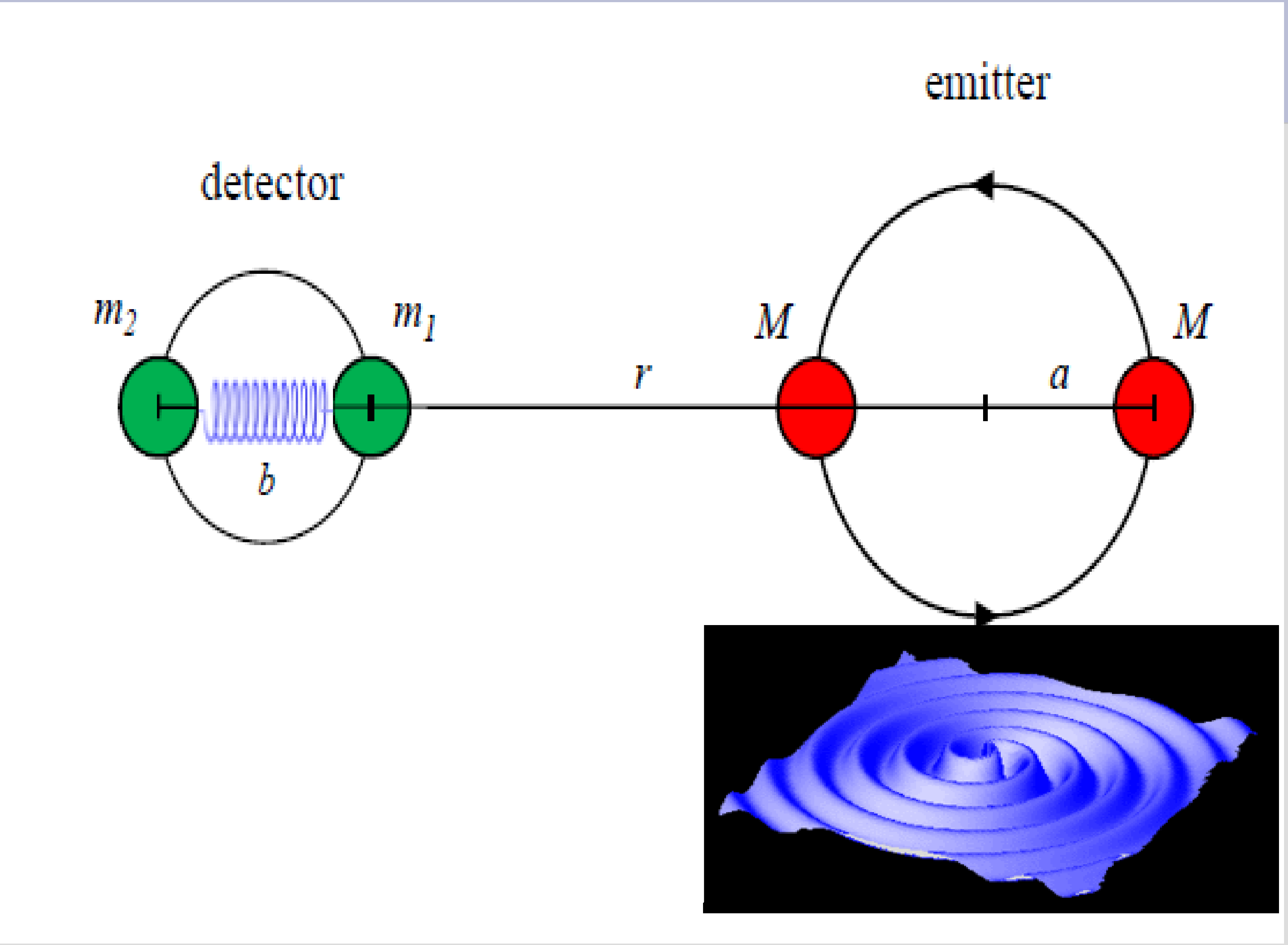
INTRODUCTION



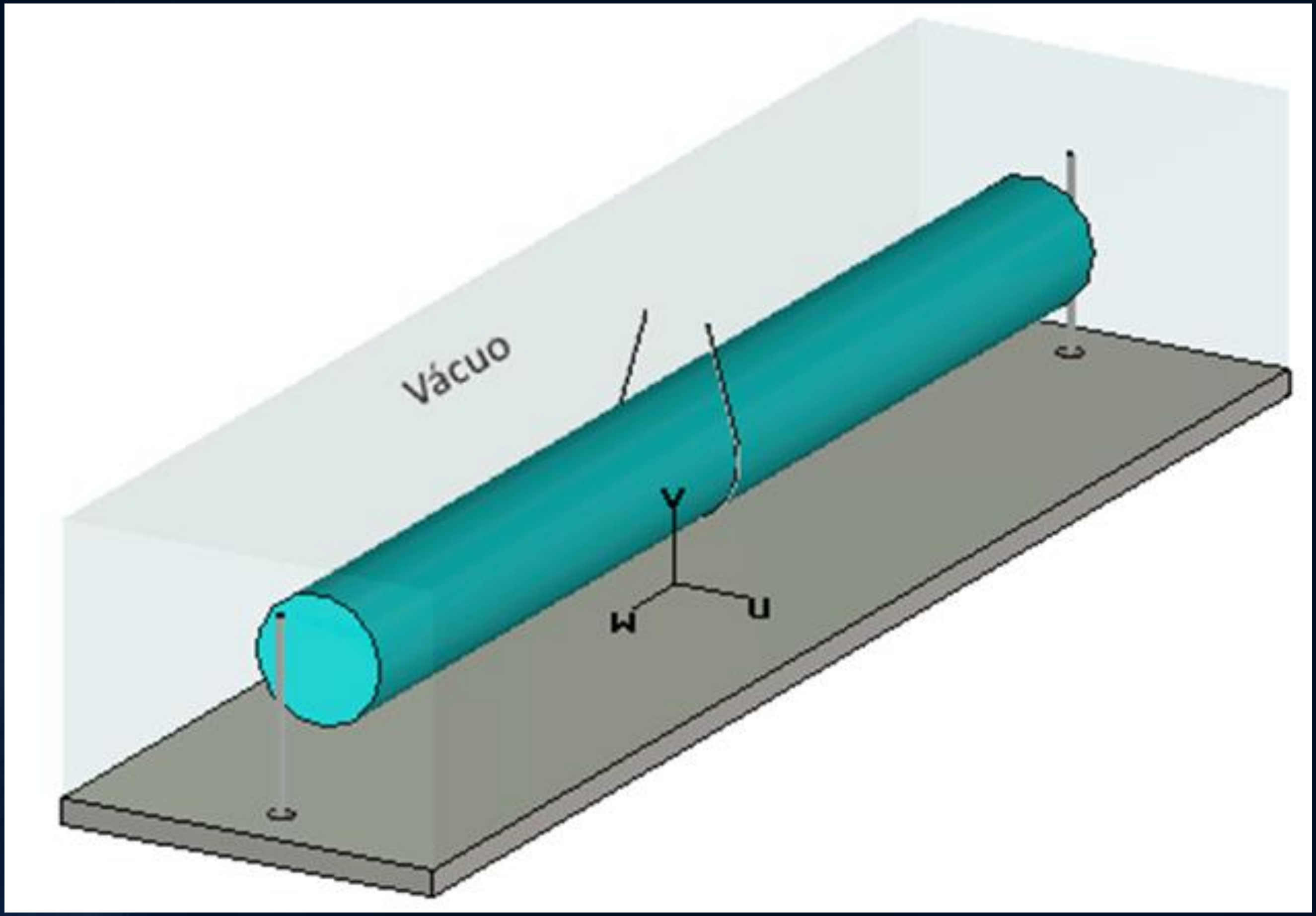


INSTITUTO FEDERAL
SÃO PAULO

THE PROPOSED EXPERIMENT

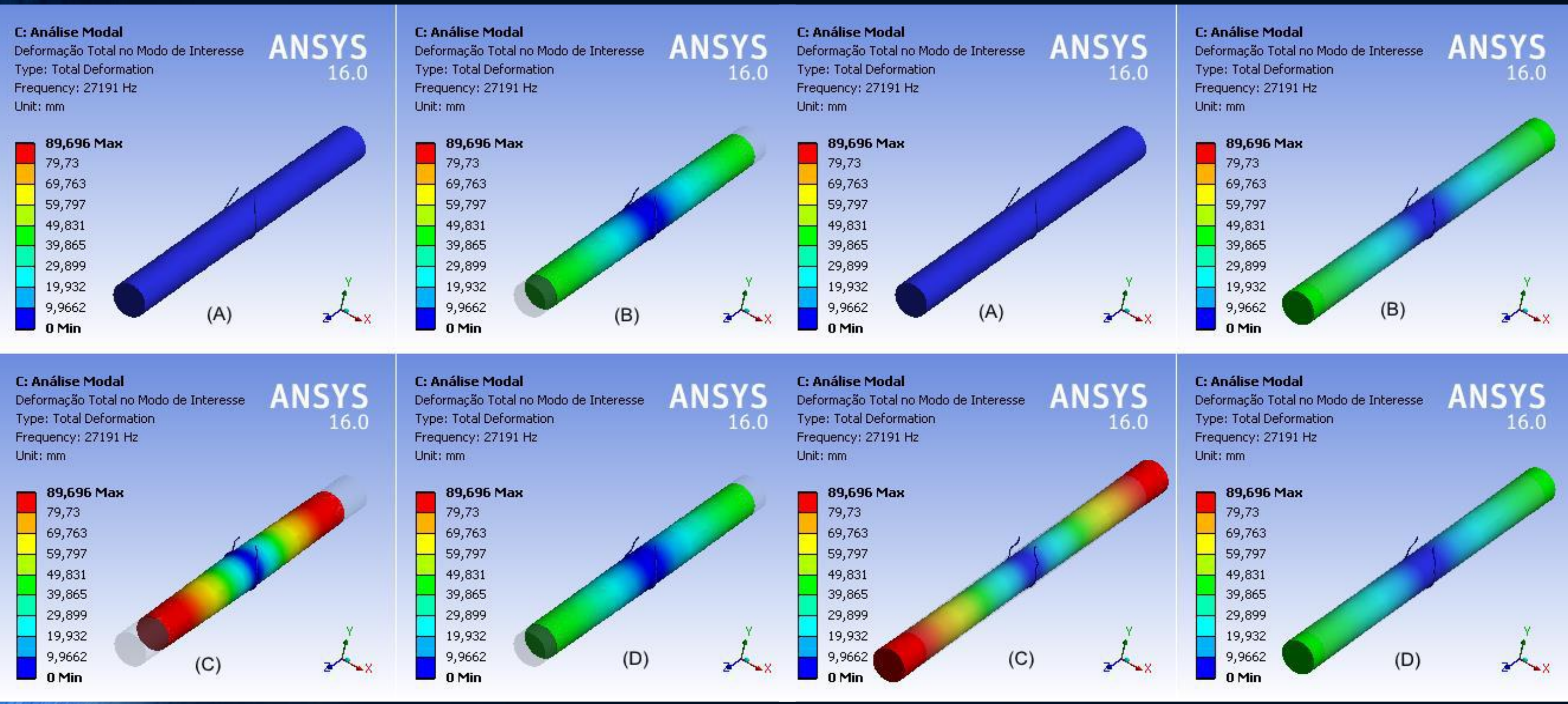


THE DETECTOR

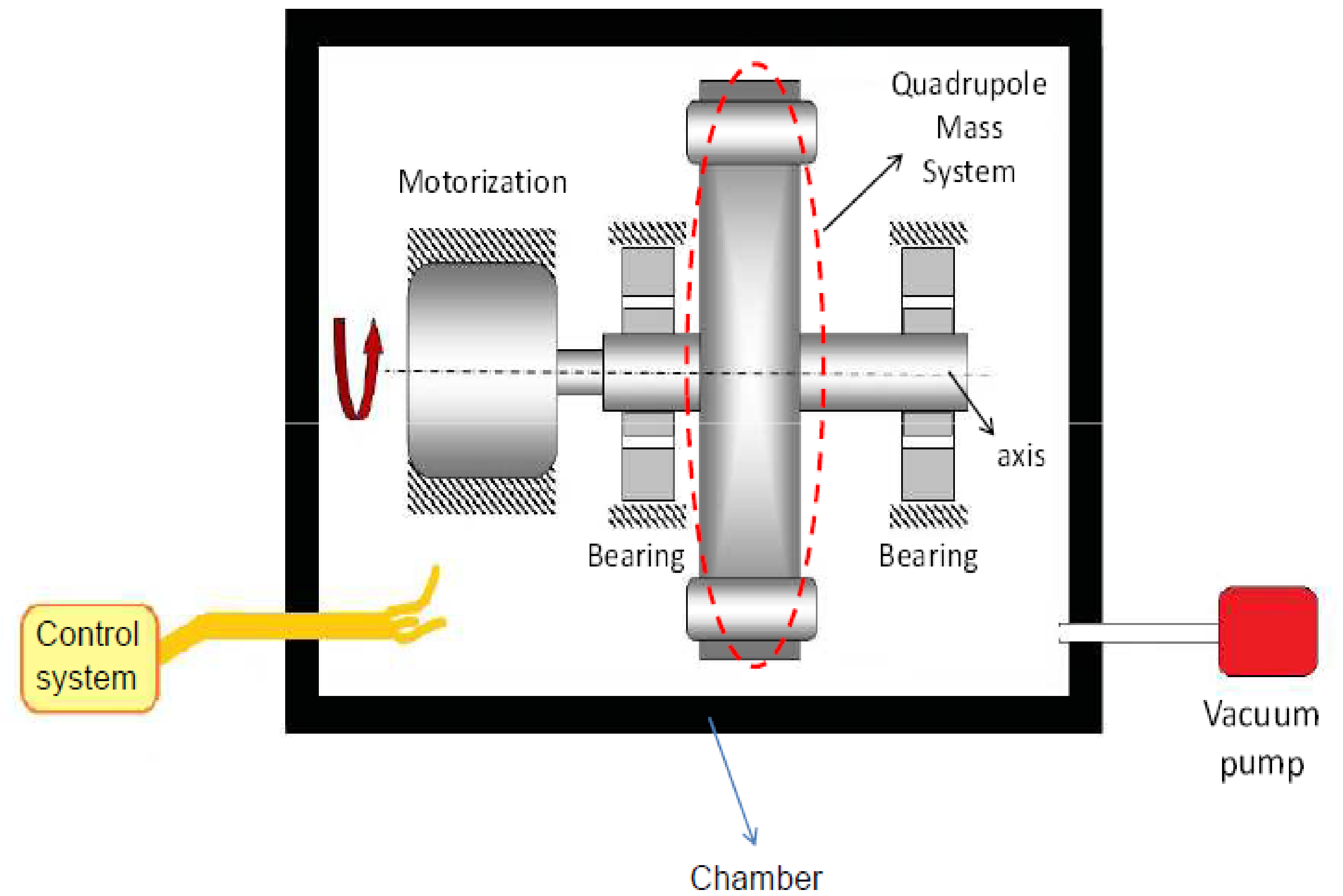


INSTITUTO FEDERAL
SÃO PAULO

THE DETECTOR



THE EMITTER



Quadrupole
Mass
System
Motorization
axis
Bearing
Bearing
Control
system
Vacuum
pump
Chamber

Quadrupole mass optimization process

For the optimization of the emitter device, a simplified modeling of the emitter-detector system has been developed. The emitter is described as a system of two masses M connected by a rod of length 2a, which rotates with axis passing through the center of mass (c.m.) and angular frequency w. The detector is described by a system of two masses m = m1 = m2 connected by a spring of natural length b and elastic constant k. A mathematical description of the emitter-detector system, described in detail in our previous work, shows the following relation for the gravitational signal amplitude h:

$$h \propto \frac{a^2 M Q}{\omega_0^2 r^5}, \qquad (1)$$

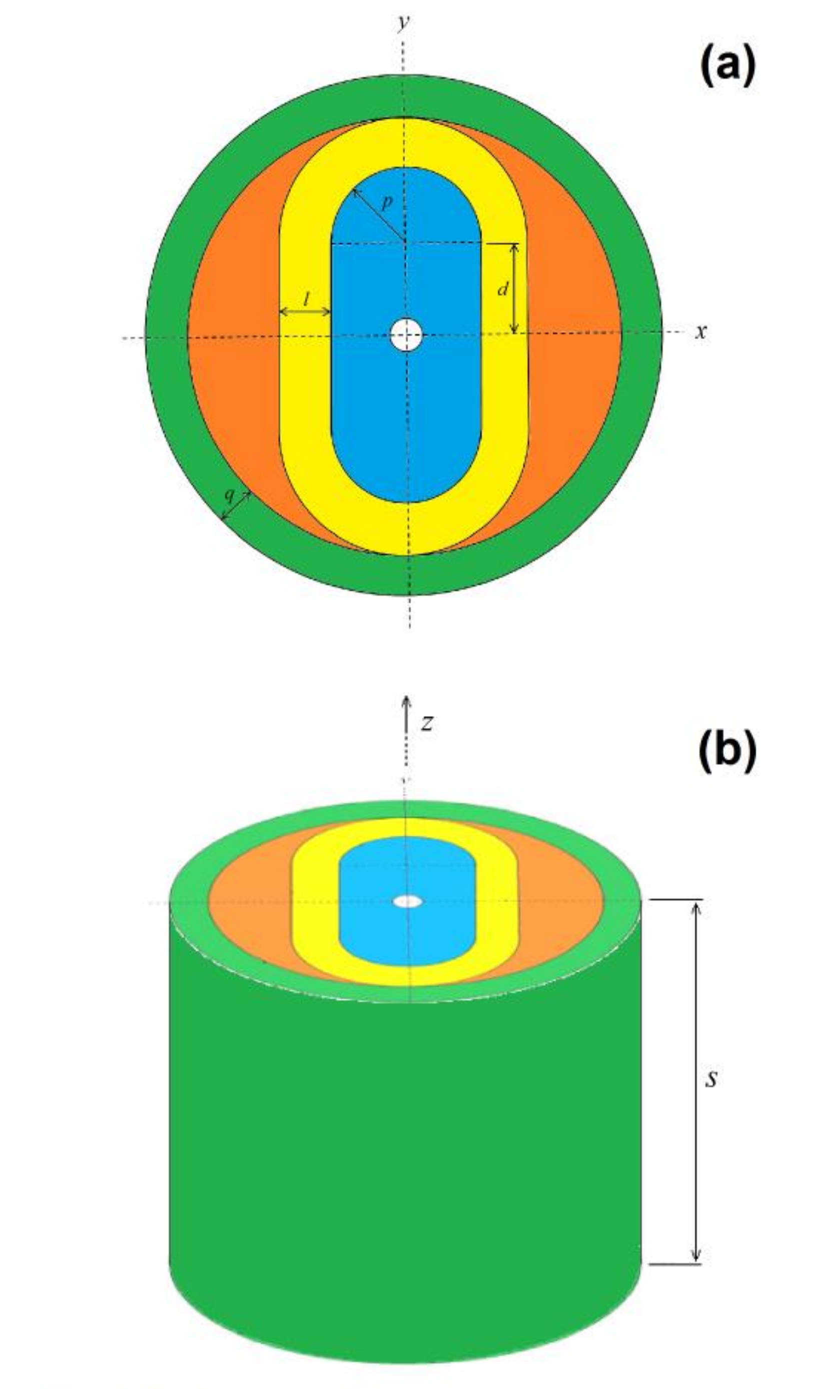
where Q the resonance frequency of the detector, and r is the emitter-detector distance. Therefore, the product a squared M is the quantity to be optimized in the emitter. A rotation frequency f = 1,600 Hz is considered in the sizing calculations. As the gravitational signal frequency generated by the rotating quadrupole mass is twice the rotation frequency of the same mass, the expected signal frequency is 3,200 Hz. This value is compatible with the central resonant frequency of the detector Mario Schenberg.

A more realistic quadrupole mass

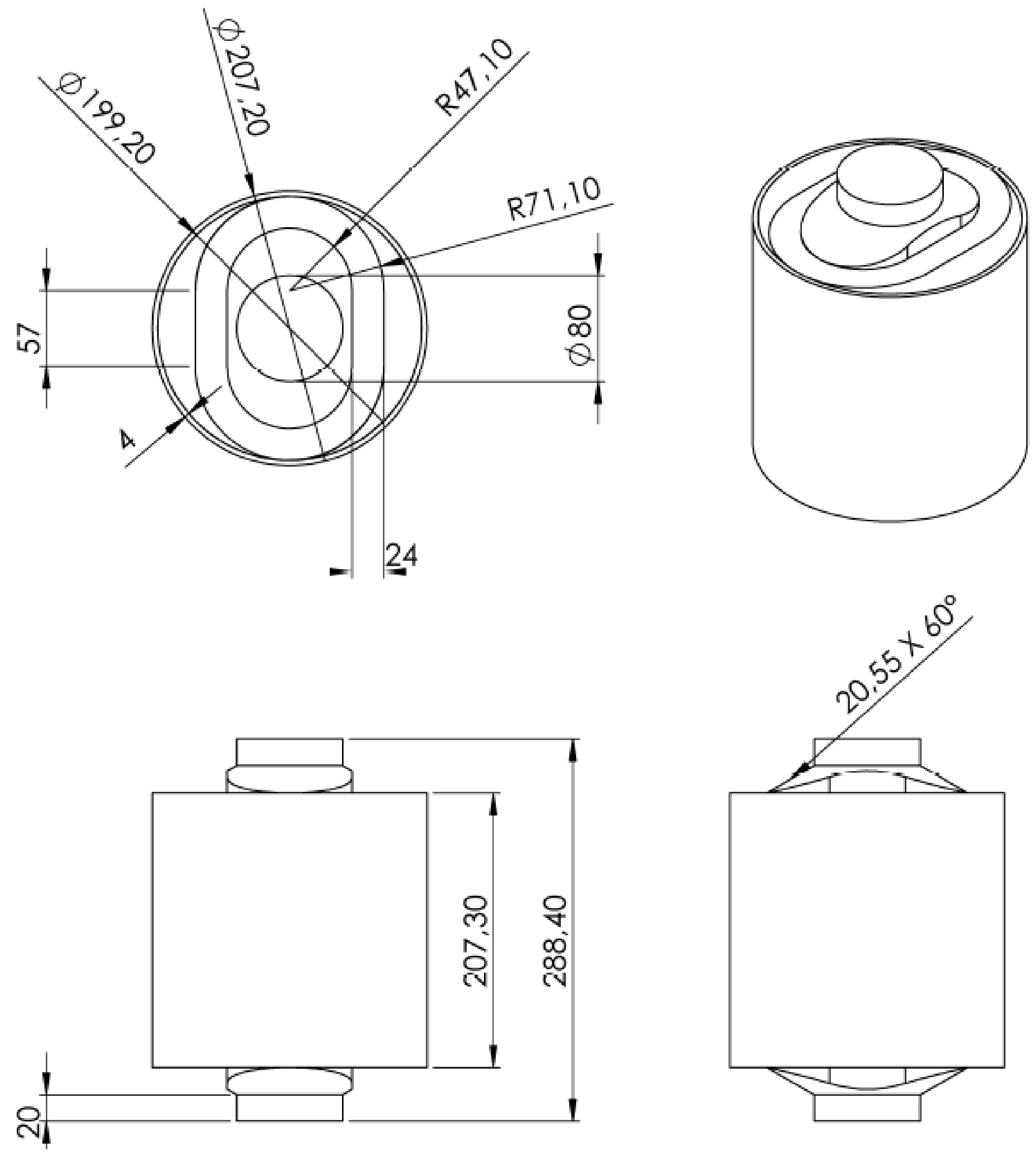
A more realistic configuration for the emitter quadrupole mass. It is a non-cylindrically symmetrical mass composed of Maraging steel (shown in blue), carbon fiber + epoxy (yellow and green), and carbon fiber laminate + epoxy (orange).

.

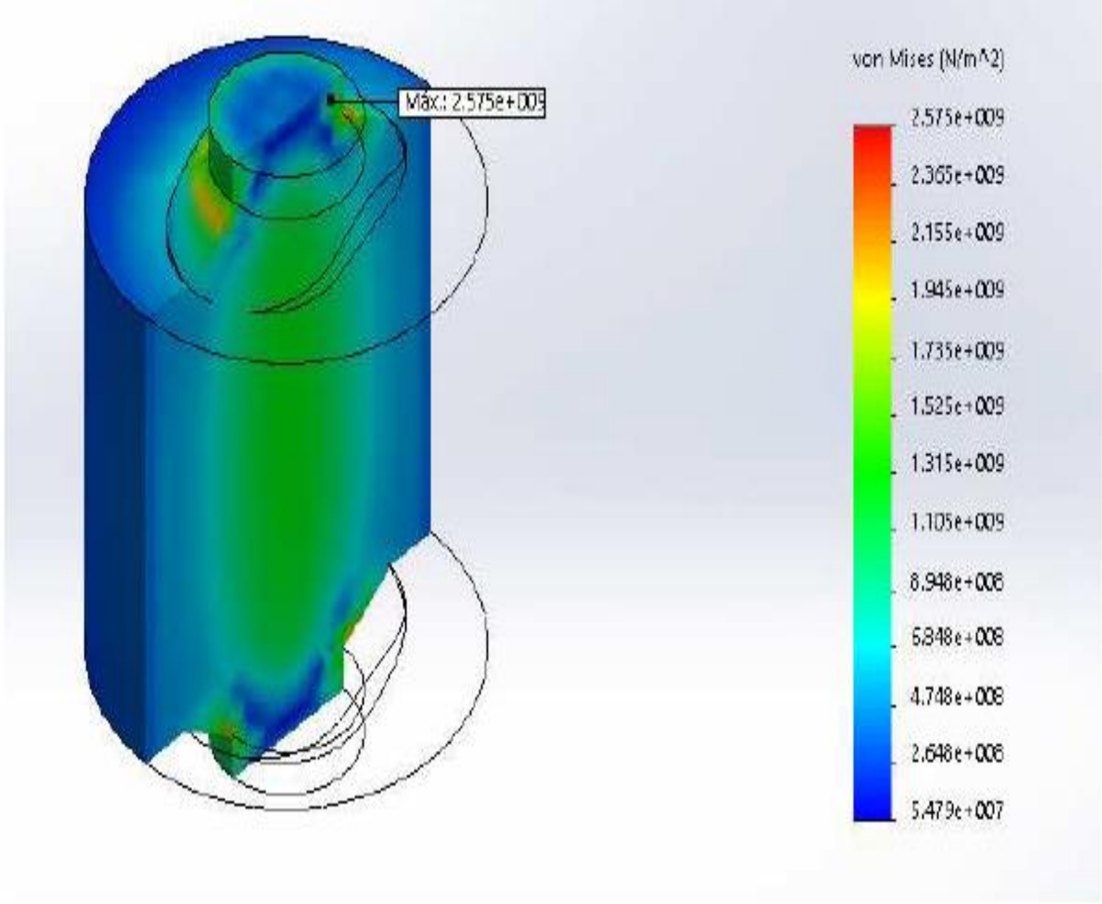
In conclusion, the FEM simulation allowed to show the feasibility of construction of the gravitational signal device, indicating that it is possible to avoid stress excess in the quadrupole mass at a rotation of 96,000 rpm.



RESULTS OBTAINED WITH FEM



RESULTS OBTAINED WITH FEM



THANK YOU!

FAPEST GRANT#2013/26258-4

REFERENCES

1. Abbott B P et al. (LIGO Scientific Collaboration and Virgo Collaboration) 2016 Phys. Rev. Lett. 116 061102
2. Abbott B P et al. (LIGO Scientific Collaboration and Virgo Collaboration) 2016 Phys. Rev. Lett. 116 241103
3. Abbott B P et al. (LIGO Scientific and Virgo Collaboration) 2017 Phys. Rev. Lett. 118 221101
4. Abbott B P et al. (LIGO Scientific Collaboration and Virgo Collaboration) 2017 Phys. Rev. Lett. 119 161101
5. Bortoli F S, Frajuca C, Souza S T, de Waard A, Magalhaes N S and Aguiar O D 2016 Braz. J. Phys. 46 308
6. Frajuca C, Ribeiro K L, Andrade L A, Aguiar O D, Magalhaes N S and Marinho Jr R M 2004 Class. Quantum Grav. 21 S1107
7. Frajuca C, Bortoli F S and Magalhaes N S 2006 J. Phys.:Conf. Ser. 32 319
8. Frajuca C, Bortoli F S and Magalhaes N S 2005 Braz. J. Phys. 35, n. 4B 1201
9. Frajuca C, Magalhaes N S, Bortoli F S and Horiguti A M 2008 J. Phys.: Conf. Ser. 122 012029
10. Bortoli F S, Frajuca C, Magalhaes N S and Duarte E N 2010 J. Phys.: Conf. Ser. 228 012011
11. Frajuca C, Souza M A, Coppede D, Nogueira P R M, Bortoli F S, Santos G A and Nakamoto F Y 2018 J. Braz. Soc. Mech. Sci. Eng. 40 319