Towards a high-performance Foucault pendulum

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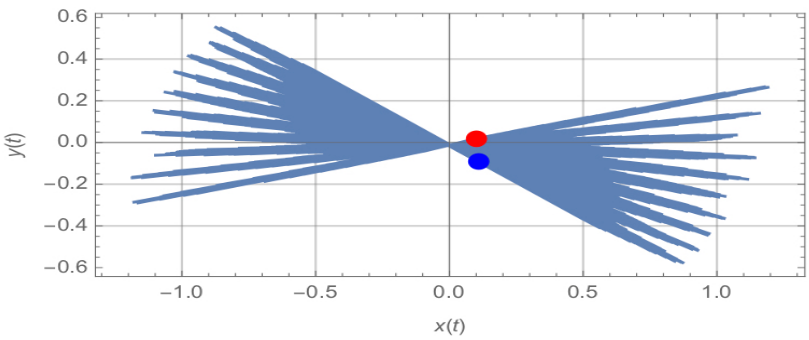
Abstract. The Foucault pendulum is considered by many to be one of the fundamental experiments of physics since it was first demonstrated by Léon Foucault in 1851. This paper shows that this fundamental experiment could be converted into a highly sensitive measurement system capable of resolving tiny precessional motions of relativistic frame-dragging.

Introduction

The authors have mathematically modelled a Foucault pendulum [1] and have shown that their tractable model performs extremely well in terms of predicting the Newtonian rotation of the Earth. The nonlinear dynamic model takes account of latitude and also incorporates parametric excitation of the length, in the form of a harmonic modulating motion of ≤ 0.01 of the nominal pendulum length, Figure 1. An experiment has also been built and tested [1] in which a 4.65 m pendulum with a linear drive system for the parametric excitation was tested over time. The results were encouraging, and the authors are designing a high-performance version to resolve the tiny motions due to the relativistic effects of Lense-Thirring precession, or *frame-dragging*, for which an approximation at any terrestrial latitude can be obtained through an analogy between Maxwellian electrodynamics and gravitomagnetism [2]. This new experimental measurement will require an increase in resolution of around 2×10^9over that required for measuring the Newtonian rotation of the Earth.



The Foucault pendulum is under principal parametric excitation with zero detuning and at 0.075m peak amplitude for a nominal pendulum length of 8m and a bob mass 2kg, located in Glasgow, Scotland, UK. The red dot denotes the start position, the blue dot the end position. Axes scaled in metres.

Figure1: Theoretical response of the Foucault Pendulum

Experimental Design

Despite the enormous challenge of resolving Lense-Thirring precession, noting that this is calculated to be of the order of 181.5 mas/year in Glasgow, Scotland [2], this has been a goal discussed by several researchers since the seminal works of Braginsky *et al* in 1984 [3], Pippard in 1988 [4], and several others since then, but not yet achieved. The main obstacle to resolving such a small precessional motion has been technological, requiring virtually the complete elimination of a large number of natural and man-made interferences [1], but the large advances made in instrumentation over the last 35 years means that this aim may now be in sight.

Conclusions

The paper summarises a novel design for a new high-performance Foucault pendulum for the resolution of Lense-Thirring frame-dragging precession on Earth, as a relatively low-cost confirmation of general relativity.

References

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