Comments on Mechanical Friction

for the Paper by M. Tajmar et al.,

Search for Frame-Dragging-Like Signals Close to Spinning Superconductors, gr-qc/0707.3806v8

Time and Matter 2007 Conference

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14 January 2008

These comments address the question how mechanical friction of the He gas might influence the output of the gyrometers by causing an additional torque.

First, although mentioned in the paper, that this analysis is not really needed, Tajmar et al. present an analysis based on the assumption of laminar Stokes flow. However, the flow could be turbulent and other fluid forces might play a role as shown below.

Most important, it follows directly from the gyro measurements that **friction does not play a major effect**. Regarding Fig. 8 in the paper, as long as the temperature is above about 30 K, the gyro signals fluctuate around 0. Since the He flux is present and the ring is rotating, the friction effect cannot change when T is lowered, since this change in the value of molecular or turbulent friction can be neglected. Therefore, the strong onset of gyro signals at around $30K$ is a sign that friction has no influence on the measured signals.

At around $30K$ the gyros start measuring an output that is only driven by T. This is a sign that symmetry breaking occurs (perhaps some kind of two-electron interaction to form bosons). Although Cooper-pair forming is a two-electron interaction, the *two types of symmetry breaking don't necessarily have to be the same*. In our physical model (*EHT*) they are different (you mentioned that *EHT* is based on superconducting, but this is not the case. We need a *symmetry breaking mechanism in order to produce gravitophotons*. We also get *different values for CW and CCW rotation*, because of the two additional ffields in *EHT* where one is axial and the other one polar).

In addition, if friction were the driving force, the *asymmetry* with respect to rotation could not be seen.

For a fluid dynamics analysis, there are several force terms resulting from the $N-S$ eqs in an accelerated frame, namely *convection force, pressure force, friction force, centrifugal force, and Coriolis force.* No explicit time dependence is assumed.

Looking at the dimensions and parameters of the rotating ring and using dimensional analysis, one can calculate a few numbers:

Reynolds number $Re = v \times L/\eta$ where v is characteristic speed, L characteristic length, η is kinematic viscosity (m^2/s). Dynamic viscosity $\mu = \eta\rho$, ρ is density. Assuming the ring rotating at $350 rad/s$ with a diameter of $1.5 \times 10^{-1} m$ and assuming $\eta = 1.5 \times 10^{-6} m^2/s$ for He (I used the value of air divided by 10 as suggested in your paper), results in a velocity of about $58 m/s$ at the perimeter of the ring, and an average velocity of $29 m/s$ was assumed. As characteristic length, the perimeter, $1m$ or the ring diameter could be used, $1.5 \times 10^{-1} m$, resulting in a Reynolds number varying from about 2×10^7 to 3×10^8. This indicates that most likely the flow is not laminar, and thus the molecular friction coefficient might underestimate the fricion force. A *linear velocity profile in the BL was assumed*, while in the *turbulent case the profile might be much steeper.*

Since we do not know the density ρ under which the He gas is operated, we cannot give a numerical value for the convection term, but one can easily calculate it from the formuala $\rho d^{-1} v^2$ where d denotes gap distance ($5 \times 10^{-3} m$).

Let us forget the static pressure force.

The maximal centrifugal acceleration that acts on the He gas in radial direction is calculated by $\omega^2 r = 58 \times 58 \times 7.5 \times 10^{-1} m/s^2$. But only a small part of the He will rotate at the same speed as the ring, thus the overall centrifugal force should be small.

The Coriolis acceleration $-2\omega \times \mathbf{v}$ depends on the speed of the He in the rotating coordinate system, but I feel that it is really difficult to predict these values, since, in reality the velocity distribution needs to be known. If the density of the He is known, the mass of the He can be determined from the gap volume $\pi r^2 d$ and the maximal force could be calculated.

In addition, we would need to check the possible contribution of the torque, τ coming from the area, A, of the rotaing ring wetted by the He (if we understood Fig.2a correctly which should be enlarged, and some more explanation would help in understanding the experiment). In case surface A is stationary and the sample holder is rotating at angular frequency ω, the torque is given by

$$\tau = 4\pi\rho\eta d \frac{r^2 r_s^2}{r^2 - r_s^2} \omega$$

where r_s is the radius of the sample holder connected to the electric (or air) motor.

If *force terms from fluid interaction are of concern*, a 3D simulation needs to be performed, which is a certain amount of work, involving grid generation, turbulent models, grid convergence studies etc.

The present conclusion is, however, that **these fluid terms are not affecting the gyro signals**.