"Testing the Clock Hypothesis using a Synchrotron Mössbauer Source "

HC - 3065

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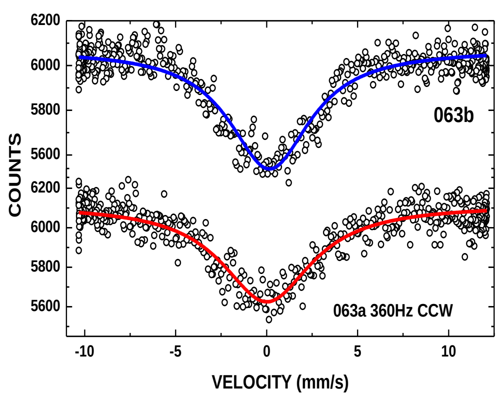
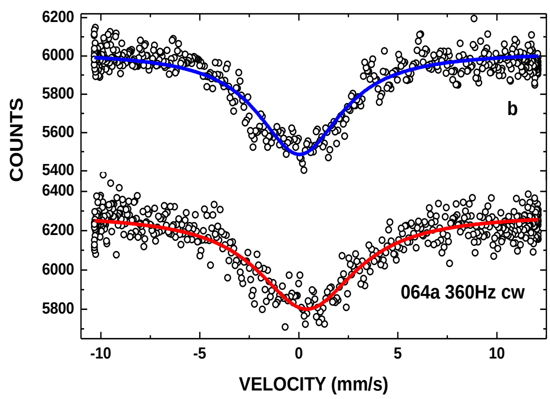
This experiment was a follow-up of experiments HC-1361 and HC-1898, with the aim to test the so-called Einstein's Clock Hypothesis, which represents a cornerstone in Relativity Theory [1]. Violation of the clock hypothesis is the influence of acceleration on time dilation. This can be proven by the detection of a significant non-zero relative spectral shift (RS) of a Mössbauer absorber in two states (a) and (b) of the rotor differing only in the direction of their respective accelerations.

The experimental findings, together with an additional know-how and their implications, acquired in the previous experiments appear in the previous ESRF reports as well as in publications [2]-[4].

In order to be more conclusive and get a better understanding of the relative spectral shift due to rotation, we performed the present experiment with an improved setup. Specifically:

1. We lowered significantly the vibrations by tightening the connection between the rotor system and the table supporting it. Furthermore, we used a stronger vacuum pump. These improvements enabled us to reach safely rotations up to 510Hz in both directions without breaking down the rotor system (in the previous experiment the system broke down at 300Hz).
2. We found a way to increase significantly the count rate by changing the temperature of the borate crystal and using more effective slits.
3. The above improvements allowed us to collect more statistically significant data for the spectra of a rotating absorber for both states (a) and (b) for several rotation frequencies up to 510Hz in both CW and CCW directions. For example, we achieved the quality spectra with best fit parameters in the table below (for runs 63 and 64 at 360Hz) in both directions, by using a new slit of 2.5 microns rotated by 10° to obtain an effective slit of 1.5 micron.





Run	Effect %	Γ(FWHM) mm/s	Shift x_0 mm/s
63a	8.02(2)	6.07(27)	0.01(7)
63b	8.78(2)	5.44(23)	0.16(6)
64a	7.75(2)	6.08(30)	0.40(7)
64b	8.91(3)	5.24(26)	0.03 (6)

The experiment, as any high precision experiment looking for relativistic effects, must: a) obtain the spectrum of an entire resonant line of a rotating absorber; b) obtain spectral lines for two separate states (a) and (b) to observe the RS between them; c) check the reproducibility of the RS within a similar configuration; c) repeat the experiment with a configuration that should not affect the RS resulting only due to acceleration; d) if the change in configuration causes a change in the RS, explore other effects that also lead to a RS; e) obtain the corrected RS by eliminating any unwanted RS; f) repeat the experiment with different configurations to verify that the corrected RS is independent of the configuration; g) check that the RS is unafected by a different absorber and/or rotor system; h) study the dependence of the RS on rotation and disk size.

In experiment HC-1361 we developed a methodology how to obtain the spectrum of a rotating absorber by alligning the beam with the center of rotation and how to use a slit to narrow the beam width at this center. In HC-1898 we improved the configuration, which in turn enabled us to reach higer rotation frequencies. We also obtained spectra for the two states (a) and (b), and observed a statistically significant stable RS. Furthermore, we discovered an unwanted shift due to the non-random vibrations of the rotor system and found a way how to eliminate them in order to obtain the corrected RS by monitoring the vibrations. Even after this correction, we nevertheless obtained a significant RS at 200Hz which is much larger than the one predicted by any model.

In the recent experiment HC-3065 we repeated the run at 200Hz keeping almost the same configuration and reproduced the corrected RS of the previous experiment. However, we found that even for any given rotation frequency, changing the size and/or orientation of the slit and direction of rotation produced a different RS. For example, in the above runs with the same rotation frequency (hence same acceleration) differing only in the direction of rotation, the RS due to acceleration should be identical. However, the above table reveals a significant change in magnitude as well as the change in sign of the RS.

This fact alarmed us and led us to conclude about the existence of another unwanted RS due to the beam-slit configuration (in addition to that caused by the inperfectness of the rotor system), with absolutely no relation to acceleration. Since the rays of the beam, emerging from the KB optics are focused (not parallel), a change of slit and/or its orientation, causes a loss of symmetry of the beam profile at the points of incidence with respect to the axis joining the KB optics to the center of rotation. We found a way to remove this unwanted RS by simply averaging two experimentally measured corrected RS in opposite directions keeping exactly the same configuration. We have checked this resulting RS, and found it to predict a more reasonable value for the maximal acceleration.

As in the previous experiments, we observed a drift in the spectrum for long runs which reduces the accuracy of the RS . We discovered that it was caused by the imperfectness of the mechanical connection of the rotor system to its supporting table in the ID18 lab. Adjusting this connection, will further reduce the vibrations, allow to reach higher frequencies, and to minimise the drift.

The above findings of this experiment compel us to submit a further proposal for another follow up experiment at the same beamline ID18 at ESRF.

References

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