MDPH480/PHYS480/ASTR480/MAPH480 Research Projects 2009

Project Title: Investigation of quantum noise limit for ring laser gyros

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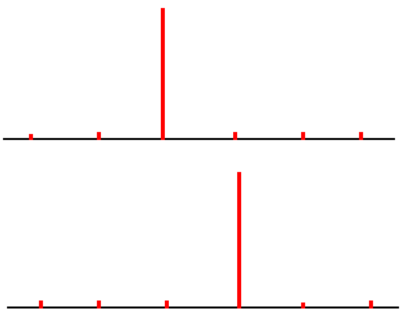
Abstract of the Proposed Research (use this page only)

The noise limit in question is the limit of the optical phase stability on the laser beams circulating in the ring lasers. The limit is imposed by residual spontaneous emission from the laser gain medium, even in the presence of the strong circulating laser beam. You can think of it as the spontaneous photons having random phases relative to the existing laser beam, unlike the photons from stimulated emission, which are in phase. The end result is that a laser beam has a non-zero line-width. The famous Schawlaw-Townes formula quantifies this.

The goals of the project are:

1 Review the derivation of the Schawlaw-Townes result. There are a number of variants of the formula, resulting from 'simplifying assumptions' not all of which are appropriate for our unusually large ring lasers with very low-loss cavities. Recommend a suitable version of the formula for our applications.

2 Look into the feasibility of *directly measuring* spontaneous emission from one of our lasers, while it is operating. This may sound unlikely. However we can exploit certain unique characteristics of our lasers. It is possible to run them in so-called 'split' modes, where the 2 counterpropagating beams have different longitudinal mode numbers. The diagram shows schematically what would be a typical spectral display of the 2 laser outputs. The tall lines represent the 2 laser beams. The small lines represent the spontaneous emissions at all the longitudinal mode frequencies. (These small peaks are in reality perhaps 10^{-6} - 10^{-7} of the height of the tall peaks.) We assume that, as usual, we mix the 2 beams in order to detect the beat frequency. (If the laser were not split this would give a Sagnac signal due to Earth rotation.) For the modes at which we have lasing, we have a laser beam in one direction, and spontaneous emission in the other. We should be able in principle to observe the beat frequency signal between these. It should be a somewhat fluctuating audio signal at a precisely known frequency, in fact the usual Sagnac frequency from Earth rotation.



3 Try to actually make this measurement, using one (or several) of the lasers that will run in this split-mode fashion (PR-1 in room 201, G-0 or UG-3 in the Cashmere Cavern). Preliminary calculations suggest it should be just about possible.

The project has a mix of theory and experiment It requires an interest in lasers and signal processing.