FYP: Phase chirp effects in optical atomic clocks

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In this project, phase shifts that occur when an acousto-optic modulator is used to switch on an optical beam will be investigated. When the beam is used to interrogate an atomic transition, the phase shifts appear to the atom as a frequency shift of the light and are hence a source of error in optical atomic clocks. The aim is to quantify this effect in a test set up, investigate what experimental parameters most influence the observed chirp, and explore any possible dependence on device model being used.

I. THESIS OUTLINE

1. **Introduction:** This should give a basic overview of the thesis. This should include information on
   (a) What an optical atomic clock is: basically a laser stabilized to a high finesse optical cavity, with an atomic transition used as a reference frequency to compensate long term drift of the cavity resonance.
   (b) what is the current state-of-the-art and what is the latest achievements for our group using lutetium. This is limited to what level of accuracy and stability is achieved.
   (c) The importance of making sure path lengths between the laser and the atom are stable and what it means if they are not.
   (d) what role AOM's have in the path-length stabilisation and the atom interrogation, and how this can influence clock accuracy
   (e) Outline of the thesis. This should include a statement on what problems/questions you seek to answer.
2. **Background:** This should cover the basic ideas on which the thesis is based
   (a) Basic ideas of accuracy and stability in an atomic clock
   (b) The Michaelson interferometer: a description of how it works, and an indication of how it plays a role in path-length stabilisation for atomic clocks.
   (c) The acousto-optic modulator: a basic description of what it is, and how it is used in the experiment.
   (d) Phase measurement technique: this is a discussion on the basic idea of how the phase is measured, not a description of the experiment.
   (e) The sensitivity function and how one can calculate the effects of phase chirps in an atomic clock experiment.
3. **Experimental setup:** This should give a detailed description of the experiment. There should be a schematic of the optical layout, a description/explanation of how phase stabilisation is done, and how the effectiveness of the phase stabilisation is assessed.
4. **Results:** This should include a discussion on how the data is analysed, and how frequency shifts are extracted from the results.
5. **Conclusions:** A short summary on what was done and to what level you can answer the questions posed in the introduction. Ideally you should be able to make a concrete statement about the dependence on RF power on the frequency shifts expected in a real experiment, what difference can be expected between the different interrogation techniques, and are there any difference between devices from different manufacturers.