Using Doppler Effect and Collimation to Study Atomic Behavior

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The research motivation of this experiment is to make technology and principles available to engineers working to advance devices such as atomic clocks, accelerometers, and gyroscopes. The clock utilizes atomic oscillation to ensure more precision. What are the most effective strategies to further understand atomic behavior for time-keeping and navigation? The investigation can impact world-class means for future developments of navigational positioning devices and atomic clocks on an atomic level. Many nations recognize their atomic clock and satellite tracking system for such purposes. As observed by those nations, the primary issue behind the investigation is the large margin of error across universal time-keeping and navigational devices. During Phase 1 (Atom-Light Interaction), we observe trajectory of atomic free space transport in ranging conditions, program visuals to record behavior from respected angles, and post-collimation w/ a light beam. During Phase 2 , we form a circuit using resistors, a microphone, and power source, and fan, connect the oscilloscope to the circuit, set source to 900 Hz and record frequency w/o fan, record new frequencies w/ fan amplifiers from various distances, and measure the Doppler Shift using the given formula. As a result of both phases, the behavior is best described as specular reflection, the atoms emit signals due to “jumping” their outer electrons, and the shift is easily changed in a controlled space. In conclusion, well collimated atomic beams can be achieved by designing novel planar structures on silicon using microfabrication that aids in miniaturizing atomic sensors (e.g. clocks) to chip scale. Doppler shifts are vital in evaluating the collimating performance and determining the precision of atomic clocks.