Tunmay Gerg ’25

Internship at Oak Ridge National Laboratory
Summer 2024

During the summer of 2024, I used my Byrne Scholar funds to conduct physics research at Oak Ridge National Laboratory with Dr. Benjamin Lawrie. I focused on generating and measuring two-mode squeezed vacuum light at optical frequencies. Two-mode squeezed light is interesting because two light modes are quantum mechanically entangled. Such a state has quantum correlations which itself is interesting, but furthermore, the noise of certain superposition quadrature operators is less for two-mode squeezed light than two-mode vacuum light. This is not only theoretically intriguing, but also practical, as it can be applied to quantum-enhanced sensing. During the first half of the summer, I collaborated with another intern to generate bright (visible with our eyes) two-mode squeezed laser beams. We demonstrated the squeezing effect by measuring reduced intensity difference noise between the two modes. This experience was particularly thrilling, as it was my first time witnessing macroscopic quantum states.

In the second half of the summer, I expanded the experiment to enable superposition field quadrature noise measurements. This setup allows for the measurement of a two-mode squeezed vacuum field—a light source similar to the previously studied squeezed light but now with only about 10 photons! This makes squeezed vacuum light particularly appealing for sensing cold materials, as its low photon count ensures minimal heating of the sample. To perform this measurement, I aligned two homodyne interferometers and piezo-actuated mirrors. By mixing the low-energy squeezed light with bright local oscillator laser beams within the interferometers, and by adjusting the phase of the local oscillators using the piezo, I successfully detected phase-dependent quadrature noise—the signature hallmark of two-mode squeezed vacuum light. This confirmed the experimental setup, but the minimum noise of the squeezed quadrature operator was only barely below the two-mode vacuum noise level. Ideally, I should have been able to measure even less noise than the vacuum level, but my time at Oak Ridge came to an end. The experiment is now being further optimized to reduce the noise measured on the squeezed beam, and the group looks to carry out quantum sensing experiments with this light source!