Applications of Helium-4 Doubly Forbidden Singlet-Triplet Transition Lines in Astronomical Spectroscopy

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Helium-4, the most common isotope of helium, is difficult to detect in the interstellar medium, as classical transitions are moderately rare; however, Helium-4 also can undergo forbidden transitions. One of these, between metastable states of Helium-4 in the 2s energy level, occurs experimentally at 1557nm in the near-infrared range; it is lower in energy and less subject to dust extinction, making it an excellent choice for the cold and warm neutral mediums. A sample of 50 nearby spiral galaxies were chosen for the study, a mostly homogeneous population. Near-infrared and radio spectra were processed, reduced, and analyzed through an independently developed procedure to correct errors, and to determine the spectral flux of the Doppler-broadened 1557nm line using a Gaussian line fit and a polynomial background approximation. Overall, in 31 of the 50 galaxies, the line was detected at a statistically significant level with high confidence, and in 6, it was detected with moderate confidence. In addition, in the sample galaxies, as expected, the spectral line flux correlated with overall H-band magnitude as defined by the astronomical magnitude system, confirming the accuracy and potential of this spectral line. Preliminary work has been undertaken for the study of the 1557nm spectral line in main sequence and post-MS stars, including the development of a procedure to adjust for errors and perform a Voigt approximation, as well as some spectral analysis. Forbidden transition spectroscopy in Helium-4, in the future, may serve as a useful tool for mapping and tracing states and masses of helium in the universe, leading to a variety of insights. As a proof of concept, a set of equations have been derived to calculate the mass of Helium-4 in the galaxy from spectral flux.

Awards Won:
SPIE, the international society for optics and photonics: Second Award of $1,500