Finding the Next Tatooine: Discovery of Giant Planets, Brown Dwarfs, and the First-Ever Circumbinary Planet Using Doppler Spectroscopy

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New discoveries are constantly being made about the origin, components, and future of our universe. To discover traces of undetected stellar and sub-stellar companions around more than 1,100 FGK stars (magnitude 8-11) cataloged in the SDSS-III MARVELS high-precision (~12 m/s) Radial Velocity survey, Doppler spectroscopy, also known as the Radial Velocity (RV) method, was employed. The RV method measures the movement of a star along the radius connecting it to Earth by observing the shifting of spectral lines due to the Doppler Effect. By analyzing the spectra of the star from ground-based telescopes for redshifts and blueshifts, stellar/sub-stellar companions were identified, their orbital properties were computed, and their masses were calculated based on the period and amplitude of the aforementioned spectral line shifts. Nine giant planet (GP) candidates; many of which were located within the Giant Planet Period Valley, were identified, as well as one new brown dwarf within the Brown Dwarf Desert. More importantly, this investigation also revealed the existence of a low-mass circumbinary planet, the first of its kind discovered using Dopplerspectroscopy. These findings have shed light on the migration, formation, and evolution of giant planets within the Milky Way. Furthermore, these results support the migration theory of GP formation. This research provides several insights into the refining of the RV method's precision to a fraction of a meter per second (especially concerning instrument systematics), which will potentially enable the discoveries of rocky planets located within their respective Stellar Habitable Zones, in addition to extraterrestrial life.

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