SPIN SYNCHRONIZATION AND ASTEROSEISMOLOGY OF THE SDB+DM BINARY B4 IN NGC 6791

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The subdwarf B (sdB) stars lie at the extreme blue end (Teff~25,000-35,000K) of the horizontal branch, and are the remnant cores of stars that have experienced the core helium flash while on the RGB. They have extremely thin (and inert) hydrogen shells surrounding a core undergoing helium fusion. How these stars form is currently unknown, though leading scenarios include mass transfer in a binary system. Single-star mechanisms have also been proposed and remain viable given the limitations of observables in these stars. The hot subdwarf star B4 in NGC 6791 is one of a handful of sdB stars known to exist in an old open cluster, and the only cluster sdB known to show nonradial pulsations and photometric variability caused by binarity. Previous Kepler data showed that this star is a rich g-mode pulsator. These modes will be used in the construction of a seismic model for the interior of this star, with additional and critical constraints given by cluster membership and therefore knowledge of its total age, metallicity, and initial mass. Additionally, B4 represents an important laboratory for the study of tidal synchronization in close binary stars. As a close binary, tidal effects should influence the rotational state of the components. Nonradial oscillations provide a measure of its bulk rotation rate. The observed oscillation spectrum shows that the sdB star rotates with a period of about 10 days - much longer than the orbital period of 10 hours. Models suggest that the time scale for synchronization should be comparable with the duration of this phase of the star's evolution, meaning that it is currently being spun up through tidal interaction. Our goals for continued observations for another year are twofold - to monitor short-period nonradial pulsations in this star and increase the S/N to expose additional modes for input into seismic models, and to study longer period variations caused by its binarity. Asteroseismic probes of this star, coupled with the additional constraints of cluster membership and the properties of the binary system, should provide important clues about the formation mechanism of the sdB stars. Given its faintness, the multiperiodic variations (45 to 90 minute periods) and the small amplitude of the pulsations, Kepler is the only instrument able to measure these oscillations to the degree of precision needed for asteroseismic analysis.Our second goal is to extend the high signal-to-noise light curve for analysis of the binary system. High-precision Kepler photometry, coupled with ground-based spectroscopy that we will obtain, can measure the orbital properties of the binary, the mass and radius of the companion, and the distance. With an additional year of photometry of the binary light curve, we can begin to place interesting limits on a tertiary components through timing variations, and to look for orbital evolution caused by tidal coupling. Only an extended, uninterrupted time series can address these issues, and at present Kepler is the only instrument capable of providing the needed data. B4 is a uniquely valuable star: a nonradially pulsating star, in a close binary system, within a cluster.