A test of the planet-star unipolar inductor for magnetic white dwarfs

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Despite thousands of spectroscopic detections, only four isolated white dwarfs exhibit Balmer emission lines. The temperature inversion mechanism is a puzzle over 30 years old that has defied conventional explanations. One hypothesis is a unipolar inductor that achieves surface heating via ohmic dissipation of a current loop between a conducting planet and a magnetic white dwarf. To investigate this model, new time-resolved spectroscopy, spectropolarimetry, and photometry of the prototype GD 356 are presented. The emission features vary in strength on the rotational period, but in anti-phase with the light curve, consistent with a cool surface spot beneath an optically thin chromosphere. Possible changes in the line profiles are observed at the same photometric phase, potentially suggesting modest evolution of the emission region, while the magnetic field varies by 10 per cent over a full rotation. These comprehensive data reveal neither changes to the photometric period, nor additional signals such as might be expected from an orbiting body. A closer examination of the unipolar inductor model finds points of potential failure: the observed rapid stellar rotation will inhibit current carriers due to the centrifugal force, there may be no supply of magnetospheric ions, and no anti-phase flux changes are expected from ohmic surface heating. Together with the highly similar properties of the four cool, emission-line white dwarfs, these facts indicate that the chromospheric emission is intrinsic. A tantalizing possibility is that intrinsic chromospheres may manifest in (magnetic) white dwarfs, and in distinct parts of the HR diagram based on structure and composition.