Constraining starspot fraction and temperature in weak-lined T Tauri stars using spectroscopy

J.H. Bootsma

Abstract

Context. Whether the gas situated in the innermost regions of a protoplanetary disk (PPD) is optically thin or optically thick determines the radial distance upward of which rocky planets (or planetary cores) can form. Obtaining information about the opacity of the inner gas is, however, impeded by a number of phenomena. One of which is the presence of starspot on the surface of stars that host PPDs. These starspots have similar temperatures as the inner gas and this makes the source of (some of) the light we receive from such star-disk system ambiguous.
Aims. We aim to constrain the starspot fraction (f_{spot}) and the starspot temperature (T_{spot}) of two weak-lined T Tauri stars (WTTS). Also, we aim to deliver a set of absorption lines that can be applied to perform this analysis on classical T Tauri stars, the hosts of PPDs.
Methods. We select three absorption lines that (1) heavily depend on both the temperature (T) and the surface gravity (log g) around the expected starspot temperature and (2) mildly depend on T and log (g) around the effective temperatures of the WTTS in our sample. We construct two-temperature model atmospheres by combining two single-temperature PHOENIX models using a certain fraction such that each model spectrum has a T_{eff} , log (g) , T_{spot} and f_{spot} . We fit these model spectra to the selected line profiles.
Results. We select the K I lines centered at 1.169, 1.17751 and 1.2525Î¼m as starspot-sensitive and we select PZ99 J160550.5-253313 and RX J0457.5+2014 as the spottiest targets in our sample. The best-fitting parameters [T_{spot} , f_{spot}] for our two targets are [3700K, 100%] and [2967K, 83%]. The results are, for each target, consistent over the three different spectral lines. The spot temperatures indeed overlap with the temperature of the inner gas. The 83% spot coverage can be explained by an inclined stellar axis. The 100% spot coverage, however, is most probably due to a methodological shortcoming. Before applying this method to CTTS, radiative transfer modeling is required to exclude that the selected absorption features will be filled in by emission from the hot inner disk.