Emission line diagnostics of magnetospheric accretion in young stellar objects

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Abstract

This thesis seeks to explain the nature of line emission observed in young stellar objects, and to use the lines as diagnostics of the accretion process that is central to star formation. We maintain that the bulk of permitted line emission is produced in free-falling gas streams formed via magnetically-mediated accretion from circumstellar disks. Radiative transfer models of magnetospheric accretion have been calculated, and predicted line profiles exhibit characteristic central peaks, blueward asymmetries, and occasional redshifted absorption components. Model Balmer line fluxes are in good agreement with T Tauri star observations. We present line profile observations of T Tauri stars spanning a range of accretion activity, and show that many optical atomic lines, such as Na I, O I, and Ca II, are qualitatively similar to the models. We find that several emission lines, such as the Ca II infrared triplet and Brγ, are well-correlated in luminosity with the accretion luminosity in T Tauri stars, and hence can be used as alternate calibrators of the accretion rate. We use the Brγ calibrator to determine accretion luminosities in optically invisible embedded protostars for the first time. The results show that protostellar accretion luminosities are only ∼10% of their bolometric luminosities, which indicates that accretion rates are on average only a factor of ten larger than in the older, optically visible T Tauri stars. We present more detailed models treating additional effects such as line damping and rotation, and show specific comparisons to well-studied T Tauri stars. Damping wings can account for the significant high-velocity emission at Hα, and produce larger Balmer decrements in better agreement with observations. Line profiles are not significantly affected by rotation at typical T Tauri rates. Using an extensive grid of models and detailed comparisons to observations, we are able to tightly constrain gas temperatures, and to some extent the magnetospheric geometry. In order to explain the empirical correlations between emission line strength and accretion luminosity, the size of the emitting region must be correlated with the accretion rate. Finally, we present models of Hα profiles and the UV/optical spectral energy distributions for two 10 Myr-old T Tauri stars in the TW Hya association. We find that the accretion rates for these stars are over one order of magnitude smaller than the mean rate for the 1 Myr T Tauri stars, indicating significant disk evolution over this time period. ^

Subject Area

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