Triggered Star Formation in a Turbulent ISM
Proceedings IAU Symposium No. 237, 2006
B. G. Elmegreen & J. Palouš, eds.

doi:10.1017/S1743921307002414

Subaru high-dispersion spectroscopy of Hα and [NII] 6584 Å emission in the HL Tau jet

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Abstract. We present slit-scan observations of the Hα and [NII] 6584 Å emission lines toward the HL Tau jet with the 8.2m Subaru Telescope. HL Tau is an active young star in transitional phase from an embedded class I protostar to a class II pre-main-sequence star, and it is located in the northeastern part of the L1551 dark cloud. The slit-scan technique at high spectral resolution (R=3.6×10^4) allowed for studying kinematics of individual features in unprecedented details. The Hα emission shows the main jet component ($V_{\rm LSR} \sim -180$ km s^{-1}) and distinct lower velocity components ($|V_{\rm LSR}| < 120$ km s^{-1}). The [NII] emission is primarily associated with the jet within 10 arcsecond from the source, and also knot B and C ∼30 arcsecond away from the source. These are associated with the main jet component, and absent in the lower velocity components. The velocity of Hα and [NII] emissions in the main jet component well matches each other.

Our high-resolution spectra do not show the evidence for the presence of turbulent mixing layers between the jet and surrounding gas. The lower velocity components are associated with individual knots, and explained as the lateral of bow shocks. Their line profiles suggest that shock velocity of the knots A-C is 120∼130 km s^{-1} (Hartigan *et al.* 1987). The observed [NII]/Hα flux ratio markedly differ between regions: 0.1-0.7 in base of the jet; less than 0.1 in knot A; ∼0.2 in knot B; ∼0.4 in knot C; and ∼0.7 in knot D. Shock models predict that the [NII]/Hα flux ratio reflects the ionization of the preshock gas. This results from enhancement of N+ via the charge exchange reaction (Osterbrock 1989; Bacciotti & Eislöffel 1999). We perform more detailed comparisons between models and observations (Hartigan *et al.* 1987; Morse *et al.* 1994). The base of the jet and knot D show high [NII]/Hα flux ratios, indicating that the ambient gas surrounding the jet is considerably ionized, or the preshock density of the ambient gas is significantly low. In contrast, the knots A-C exhibit low [NII]/Hα flux ratios, indicating that the ambient gas surrounding the jet is almost neutral, or the preshock density of the ambient gas is significantly high. The [NII]/Hα flux ratio increases from knot A (< 0.1) to knot D (∼0.7). This suggests that the ionization fraction of the ambient gas increases away from the source, or the preshock density of the ambient gas decreases away from the source.

Keywords. stars: individual (HL Tauri) – stars: pre-main-sequence – ISM: jet

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