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Research Interests and Plans

My research interests are focused primarily on understanding the formation and evolution of young stars, their circumstellar disks and their associated outflows of material. I have observed extensively at optical through mid-infrared wavelengths at many ground-based observatories (with more than 130 nights observing at Gemini North alone). I have experience reducing and analyzing data from ground and space based observatories (including HST WFPC-2 and STIS) and have enjoyed using a wide range of astronomical resources for my studies - from very high spatial resolution infrared adaptive optics data obtained at 8-10 meter class observatories (Beck et al. 2004; Beck et al. in prep.) to 100 year-old photographic plates from the Harvard College Observatory archive that were acquired with a 1.5 inch refracting telescope (Beck & Simon, 2001). I am the primary investigator for two projects that I plan to continue in the future but will mention only briefly here: 1) To gain a clearer understanding of how water-ice in disks around young stars is chemically and thermally processed by accretion activity, I have initiated a survey of the 2–4 μm spectra of ~45 stars observed through and embedded within the Taurus and Ophiuchus dark cloud complexes (Beck 2006, submitted to AJ, Beck et al. in prep.) and 2) I have used very high spatial resolution imaging and spectroscopy to understand the multiplicity fraction and natures of binary stars in their early phases of formation (Beck, Simon & Close 2003; Beck et al. 2004b).

Mass outflows of material are observed in several environments in astronomy, from young stellar objects (YSOs) to the distant nuclei of active galaxies. Studying outflows from the nearby YSOs provides the opportunity to examine jet structure at the highest obtainable spatial resolution. To date, it is unclear how mass infall and accretion onto a protostar results in mass outflows seen as jets and Herbig-Haro (HH) objects. However, the outflows likely regulate accretion onto a star by removing excess angular momentum from the system. In this way, the efficiency of the outflows (or lack thereof) will likely determine the ultimate stellar mass. Thus, understanding the infall-outflow process and how it moderates mass accretion has become a fundamental goal of modern stellar astrophysics.

In the past few years, I have become increasingly involved in investigations of the nature of YSO outflows using the comparably new technique of integral field spectroscopy (Beck et al. 2004a; Beck et al. accepted to AJ, Beck et al. in prep). Integral field units (IFUs) provide spatially resolved imaging spectroscopy at optical and infrared wavelengths. By measuring structure in spatially resolved emission lines, IFUs permit the direct study of kinematics, excitation states, and electron densities in YSO jets. For example, line ratios of the optical Sulfur [S II] 6717 and 6731 Angstrom transitions provide a direct measure of the electron densities in a region. Spatially resolved IFU spectroscopy of the spectacular HH 34 jet have revealed a pronounced "striped" structure in electron density (Figure 1). This proves for the first time that high electron density regions lie at the leading side of each outflow emission knot, which is in direct agreement with theoretical predictions of the structure of YSO outflows (Beck et al. accepted for publication in AJ).

Over the course of the last decade, high spatial resolution HST and adaptive optics imaging studies have discovered well-collimated outflows and "micro jets" from YSOs. In fact, HST STIS spectral observations of a small subset of these sources show evidence for rotation in the inner jet channels. The measured rate of jet rotation is roughly equivalent to the expected orbital velocity of material in the inner circumstellar disk, which implies there may be a connection between the inner disk and outflow. However, the marginal rotation signature found by stepping the STIS spectral slit across the YSO jet has met with skepticism, and alternative interpretations also seem plausible. Confirmation and characterization of jet rotation signatures could provide important observational support of the theoretical "disk-wind" models that are adopted to explain the inner structure of YSO jets.

The near infrared adaptive optics fed IFU, NIFS, at Gemini North Observatory provides imaging spectroscopy at resolutions as fine as ~14 AU toward nearby YSOs (0."1 at ~140pc distances) and to <20km/s velocity accuracy. The specifications of NIFS are virtually identical to STIS, and NIFS is presently the only instrument that can continue the difficult measurements of jet rotation. As a result, I have initiated survey of YSO jets using NIFS in order to better understand the velocity structure in outflows and confirm rotation in the inner channels. Figure 2 presents the velocity structure seen in forbidden [Fe II] 1.644μm emission in the YSO jet associated with the young star HV Tau C. The velocity analysis shows a ~20km/s shift across the axis of the blue-shifted jet (designated by the red line), which could be indicative of rotation in the inner bow shock. Follow-up observations of this star at Gemini North are scheduled for December 2006 Director's Discretionary (DD) time to verify that this velocity shift is caused by rotation and not by short-lived turbulent motions in the inner jet channel. In the future, I plan to continue using integral field spectroscopy (at Gemini and elsewhere) to study the velocity structure in the inner jet channels to confirm or refute the existing models and better understand how outflows moderate mass accretion onto protostars.