

Mass Feeding and Feedback in Young Stellar Objects

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Ever wonder how solar-mass stars form?... And why all the solar planets lie in a plane? Paradoxically, outflows are a prominent feature of star formation. In order for material to accrete onto a protostar it has to lose angular momentum. The angular momentum of a large natal cloud leads to the formation of a circumstellar disk and inner accretion disk as the cloud collapses. Planets ultimately form in the disk - hence the solar planets lie in a plane. Winds generated in the inner disk or close to the stellar surface (we don't know which) expel material along the disk rotation axis. These micro-jets of expelled material are seen as arcsecond-scale elongated outflows in forming T Tauri stars. We believe that these outflows are magnetically driven and that angular momentum is carried away in the partially-ionized flow through the coupling between the magnetic field and the gas. This loss of angular momentum acts as a throttle to control the rate at which other material can accrete onto the star and build up its mass.

We are investigating how these processes occur, both theoretically and observationally. Raquel Salmeron has developed localised models of both accretion and outflow mechanisms close to the star. Centrifugally-driven magnetic winds can be initiated either as material is funneled onto the star and/or launched off the disk surface by the action of strong magnetic fields that thread the disk. The radial extent over which the last mechanism occurs is not known as yet but it is believed to extend to distances of the order of a few AU (the earth-sun distance) from the central star. These spatial scales are unobservable even in nearby star-forming regions. Peter McGregor has built the NIFS adaptive-optics-corrected integral-field spectrograph on the 8-m diameter Gemini North telescope. This provides the highest resolution observational data on nearby young stars. He has NIFS data for several T Tauri stars that resolve their micro-jet outflows. Ralph Sutherland has developed the Fyris Alpha hydrodynamics simulation code. We plan to use this code to model the progress of T Tauri star jet winds through their circumstellar envelopes.

Our goal is to couple the disk-wind parameters from accretion-disk models with the outflow simulations in order to reproduce the detail seen in our NIFS data. We already know that T Tauri star jets entrain little of the surrounding envelope material, so the micro-jet emission is largely from material expelled directly from the inner disk region. Marginal observational evidence for axial rotation of the micro-jet has been claimed by others. If true, this supports the disk wind hypothesis. Our NIFS data can address this important issue.

A range of projects associated with this work can be offered at different levels (PhB, Hon, PhD). They will appeal to students with strong mathematical and computing skills who have an interest in modelling and drawing comparisons with observations.

Figures:



Fig. 1: Hubble image of the Orion Nebula. In addition to the massive stars of the trapezium near the centre, this stellar cavern contains 700 other young stars at various levels of formation. Their occurrence here lends support to the idea that planetary systems are common. High-speed jets of hot gas spewed by some of the stars appear as thin curved loops sometimes with bright knots on their ends (lower left).

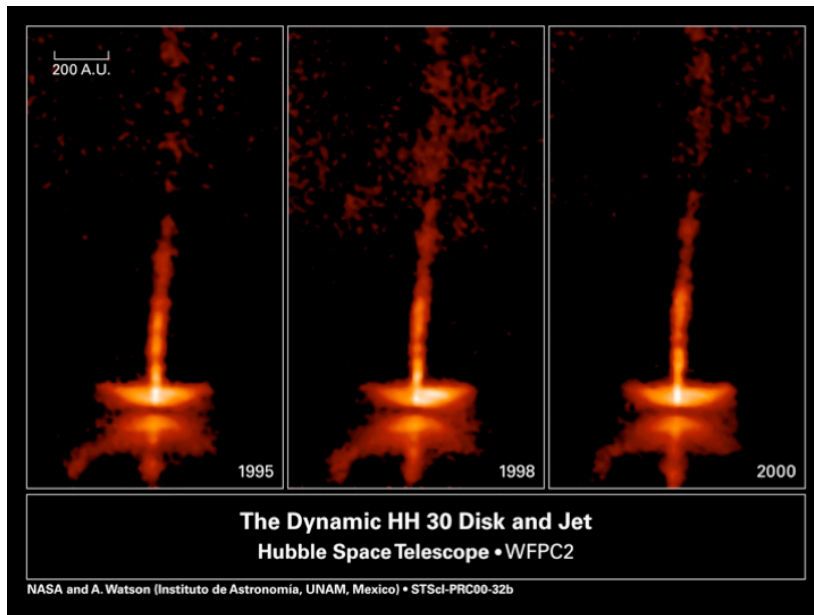


Fig. 2: Changes over only a five-year period in the disk and jets of this newborn star. Note the edge-on disk, which appears as a flattened cloud of dust split into two halves by a dark lane and blocks light from the central star. The gaps between the compact knots of gas seen in the jet indicate that launching is sporadic. By tracking the motion of these knots the jet speed has been estimated to be ~ 260 km/s, which is fairly typical.

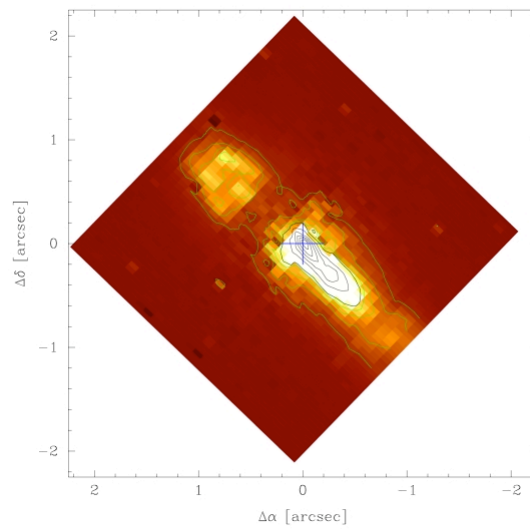


Fig. 3: [Fe II] 1.644 micron emission from the micro-jet of the active T Tauri star DG Tau obtained with NIFS on the Gemini North telescope. The full NIFS data cube contains excitation and kinematic data for this and other near-infrared emission lines at near-diffraction-limited spatial resolution.