

SS Projects for Astrophysics Students for 2006-2007

AP1. Searching for Protoplanetary Disks Around Young Brown Dwarfs

Supervisor: Prof. Tom Ray

Location: Dublin Institute for Advanced Studies, 5 Merrion Square, D2

Further information: tr@cp.dias.ie

Description:

Brown dwarfs are sometimes known as "failed stars" since they are not massive enough to ignite normal hydrogen into helium in their cores. When young (at most a few million years old) however they shine like pre-main sequence stars, i.e. through gravitational contraction. Recently evidence has been accumulating that, also like young stars, they are surrounded by disks. The goal of this project is to examine recently acquired infra-red spectra from the Spitzer Satellite to look for evidence not only for disks but for disk evolution (e.g. by changes in their amount of amorphous/crystalline silicates). Such changes would hint at the possibility of planetary formation.

AP2. Probing Jets from Young Stars through Optical/Near-Infrared Spectroscopy

Supervisors: Dr. Emma Whelan and Prof. Tom Ray

Location: Dublin Institute for Advanced Studies, 5 Merrion Square, D2

Further Information: ewhelan@cp.dias.ie

Description:

The phenomenon of mass outflow from young stellar objects (YSOs) is arguably the most spectacular stage in the formation of a new star. While there are indeed many aspects to the study of protostellar outflows, much emphasis is being placed at present on obtaining an understanding of the central engine from which the fast well-collimated jet is launched. There are several competing models to explain the launching and initial collimation mechanism for accreting protostars. High angular resolution observations of the central engine are vital to constrain such models and uncover a true picture of jet formation. However probing the region of the central engine has traditionally proved difficult. Direct imaging for example is challenging due to contamination by stellar radiation. Intermediate resolution spectroscopy helps to overcome this problem, however the resolution of ground-based observations is also seriously limited by atmospheric seeing. Pioneering techniques like interferometry help overcome the limitations imposed by atmospheric turbulence but at present are still difficult to implement. In the meantime the analytic technique of spectro-astrometry when applied to an intermediate resolution spectrum, can offer the observer information on comparable angular scales to interferometry.

The aim of this project is to reduce and analyse spectra of a small sample of classical T Tauri Stars (CTTSs). CTTSs are low mass young stars, that drive optically visible jets and are precursors to stars like our own Sun. A combined optical/infra-red approach has proved very effective at providing a useful picture of the jet launch region. In particular optical/infrared forbidden emission lines are now known to be strong tracers of outflow activity in CTTSs. For each CTTS in the sample, an optical spectrum taken with the Intermediate Dispersion Spectrograph on the Issac Newton Telescope on La Palma and an infrared-spectrum obtained with CGS4 on the United Kingdom Infrared Telescope in Hawaii, will be analysed and assessed for the suitability of applying spectro-astrometry. The ultimate goal of the project is to investigate the spatial properties of emission lines like H-alpha and Paschen-beta, with the aim of uncovering any outflow component in these lines.

AP3. Stellar atmospheres - finding all the opacity

Supervisor: Dr. Simon Jeffrey

Location: Armagh Observatory

Requirement: II2 or above

Description:

Stellar atmosphere models depend entirely on the correct treatment of stellar opacity. This is crucial for chemically peculiar stars where either the absence of hydrogen or the consequences of radiatively driven diffusion give added weight to the influence of line opacity. In the Armagh models, we currently consider over 10^7 atomic transitions with measured or semi-empirical gf-values. Theoretical atomic physics calculations predict many times this number. The object of this project will be to include all available Opacity Project and Iron Project gf-values in the opacity sampling to verify their impact on model atmospheres for early-type stars.

AP4. Opacity in chemically peculiar stars - the lambda Boo phenomenon

Supervisor: Dr. Simon Jeffrey

Location: Armagh Observatory

Requirement: II2 or above

Description:

The lambda Bootis stars are a class of chemically peculiar A stars which are deficient in metals (by up to 2 dex), but have nearly solar abundances of C, N, O, and S. They show an unusual ultraviolet flux distribution. The question is whether these stars have extremely stratified atmospheres, in which most metals have sunk just below the optical line forming region, or whether the abundances are due to some external forcing. This project will use the IUE and HST archive of lambda Boo star spectra and new techniques developed in Armagh to model chemically stratified stellar atmospheres.

AP5. Stellar Evolution - theoretical models of extreme horizontal-branch stars

Supervisor: Dr. Simon Jeffrey

Location: Armagh Observatory

Requirement: II2 or above

Description:

Recent observations of hot subdwarfs have identified several groups of "extreme horizontal branch stars" which can be clearly separated on a Hertzsprung-Russell diagram. It is thought that there are three or four ways in which a binary star can evolve to become an EHB star. This project will create a variety of stellar models using different assumptions about previous evolution and attempt to simulate the observed distribution of hot subdwarfs.

AP6. Lightcurves of Gamma Ray Burst sources

Supervisor: Prof. E.J.A. Meurs

Location: Dunsink/DIAS

Description:

Gamma Ray Bursts (GRBs) are short, intense flares of highly energetic gamma-ray radiation. In 50 percent of the cases the gamma ray bursts are followed by an afterglow that may be observed at other wavelengths, notably at X-rays and in the optical. In this project we want to study details of the subsequent fading of the GRB afterglow, which continues over weeks to months after it has been detected (for the so-called long-soft bursts). Interesting aspects of GRB lightcurves include colour evolution, constraints on the presence of initial optical flares superposed on the usual decay, and recognizable contributions from supernovae. We have access to data obtained with a small robotic telescope dedicated to GRB follow-up observations.

AP7. Tracing Particles from the Sun to the Earth's Ionosphere

Supervisor: Dr. Peter Gallagher

Location: TCD

Description:

The ionosphere is a region of the Earth's upper atmosphere in which there are a significant number of ions and free electrons. These particles, which are primarily created by cosmic radiation and solar flares, enable the ionosphere to reflect certain frequency radio waves that propagate in the ground-ionosphere waveguide. The aim of this project is to use the School's recently installed Very Low Frequency (VLF) radio wave receiver ("AWESOME") to monitor changes in the ionosphere, and to relate these changes to energetic events on the Sun. Students will have the opportunity to work closely with researchers at Stanford University.

AP8. The Sun's Magnetic Cycle: Where are we now?

Supervisor: Dr. Peter Gallagher

Location: TCD

Description:

Sunspots were first described by Galileo Galilei in the 1600's, when he trained his telescope on the visible disk of the Sun. Today it is known that sunspots are intense magnetic field concentrations on the Sun's surface that also show an approximate 22-year activity cycle. The aim of this project is to analyse magnetic field measurements obtained by the Michelson Doppler Imager on board the ESA/NASA Solar and Heliospheric Observatory (SOHO), and to investigate how sunspot groups vary with the solar cycle. The ultimate goal will be to estimate the Sun's current point in its cycle, and to compare these results with the predictions of solar dynamo models.

AP9. Solar Flares and Mass Extinctions: Science fiction or science fact?

Supervisor: Dr. Peter Gallagher

Location: TCD

Description:

There are many theories as to why mass extinctions have occurred on the planet Earth. For example, the impact of a comet or meteorite is regularly used to explain the extinction of the dinosaurs approximately 65 million years ago. A much less studied mechanism involved bursts of ionising radiation from solar flares and coronal mass ejections. A massive flare, or possibly an extended period of elevated solar activity, may have been capable of driving a global extinction. This project will focus on calculating the largest solar flare theoretically possible and estimating the radiation fluxes likely to be observed at the Earth's surface. The effects of a varying terrestrial magnetic field strength will also be taken into account, in an effort to resolve this long-standing question.

AP10. Studying mass loss in red giant stars

Supervisor: Dr. Cian Crowley

Location: TCD

Description:

After spending most of their lives burning hydrogen on the main sequence, the large majority of stars (including the sun) will evolve through the red giant (RG) phase before finally ending their lives as white dwarfs. Upon entering the RG phase the nuclear processes in the star's interior change fundamentally, synthesising hydrogen into progressively heavier elements. This results in large increases in luminosity, radius and a cooling of the surface layers. The structure becomes increasingly pulsationally unstable with more and more material being lifted off the surface in the form of a massive stellar wind. The wind carries the results of the internal nuclear processes and provides the building blocks for future generations of stars, planetary systems and possibly life. Despite the importance of these events

much is still unknown about RG mass-loss in general, and indeed the evolution of the outer layers of these stars.

The analysis of high-resolution absorption line profiles in both optical and ultraviolet (HST/STIS + FUSE) spectra of RG stars that are in binary systems can provide such needed information on these winds. Study of the optical data provides information on abundances and dynamics in the stellar atmosphere (very base of the wind), while analysis of the shapes of the profiles in the ultraviolet data provides a direct viewing of the outflowing wind which allows the physical structure and thermal conditions to be derived. An analysis of the multi-wavelength dataset will provide new insights into the mass-loss processes of these common yet spectacular objects.

AP11. Light-curve variations as indicators of stellar internal structure

Supervisor: Dr. Brian Espey

Location: TCD

Description:

The variations in brightness of late-type giant stars are largely due to oscillations in the stellar radius. For some stars this leads to well-behaved repeatable variations with a characteristic period that depends on the star's structure and chemical abundances, but for others the period is less regular. These systems may be the most interesting as if the complex lightcurve is due to more than one period (either overtones or flipping between attractors in phase space) then we can learn much more about the internal structure of the star from its oscillation modes. For one such system (Z Ursae Majoris) we see tell-tale signs of light variations that betray such complexity and, in addition, epochs when the oscillations die down for years before recovering, giving us the potential of determining the fundamental oscillation frequency as this should be the mode that grows the fastest at such times. The project will involve the analysis of roughly 64,000 amateur observations of Z UMa spanning roughly 70 years to attempt to elucidate the behaviour and internal structure of this fascinating object.

AP12. Quasars as markers of star formation and "cosmological candles"

Supervisor: Dr. Brian Espey

Location: TCD

Description:

Quasars are the most continuously luminous objects in the Universe and enable us to study their physics and environment at the highest redshifts. Observations indicate that processed material is present in the emission and absorption line regions of quasars at whatever redshift we examine, telling us that the near-nuclear environment of these objects is metal rich even at earliest times (viz. within 1 Gyr of the formation of the Universe). Utilising these observations, we can attempt to understand the process by which stars, black holes and galaxies formed but, in addition, utilise the quasars themselves to map the high redshift Universe. This

latter topic uses a property called the Baldwin Effect to relate the strengths of the emission line equivalent widths to the underlying ionising continuum, and hence to determine the quasar luminosity. By comparing the predicted luminosity and the observed brightness here on Earth, we can determine the luminosity distance of the quasars. Comparisons of this distance with models predicting the relationship between redshift and distance should enable us to discriminate between competing cosmological models (Lambda cosmology, quintessence etc.)

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