Undergrad 4th Year Project

Topic: Combine data from multiple telescopes to extract the temperature, mass, & luminosity of the Star Forming Region

Objective:
The student will:

- learn about the basics of the star formation
- learn about the radiative transfer equation
- learn image photometry
- will use Spectral Energy Distribution model and perform line fitting to extract Temperature, Luminosity & Mass of the Star forming Region

Transferable Skills:
The student will gain skills on:

- conducting a research
- line fitting algorithm
- image and data analysis
- collaboration
- presenting

Proposal:

INTRODUCTION: Stars are constantly being formed in galaxies via gravitational condensation of the interstellar medium (**ISM**, Goldreich & Kwan, 1974). Studying the physical conditions of dark molecular clouds, such as temperature, density, size, mass, etc., therefore, provides us the basic information to understand how the clouds themselves form, how they evolve, and where and how star forming structures form within them. However, recent observations with the Herschel Space Observatory (HSO) have shown that the dominant form of structure in the dark/molecular ISM is filamentary (André et al., 2010). These structures are observed in atomic and molecular gas, as well as dust. The filaments, at some point, become unstable to perturbations (turbulent/gravitational/magnetic etc.), **which lead to formation of higher density subunits spaced along the filament's axis. These regions are referred to as "clumps"** and defined as coherent regions in position-velocity space that may, themselves, contain significant substructure (Williams et al., 2000). **Clumps are the hosts for young stellar clusters** (e.g. Bergin & Tafalla, 2007). Thus, studying these clumps is the key to understanding the formation of stars and stellar clusters.

Stars, protostars, and the dense cores forming them are sufficiently dense that they can be considered to behave like Black-bodies. The situation, however, is more complex. First, since interstellar dust is not a perfect black body one has to use a modified Planck function to describe the radiation it emits. This is often referred to as "gray-body" emission. Secondly, **as the star forming regions evolve, the characteristics of their emission will change, primarily due to changes in the temperature** and the fact that the observed emission will be a combination of the embedded protostar, and the surrounding dense core envelope. Thus, the radiation intensity as a function of wavelength is no longer described by a simple Planck function but by a complicated combination of gray-bodies. **A plot of radiative flux (F) versus the wavelength (λ) is called the Spectral Energy Distribution (SED). Examine the SED is the key to extract the physical condition (i.e. temperature, luminosity, & mass) of the star forming region**.

OBSERVATIONS: Throughout this project we utilize the imaging data from different telescopes to extract the SEDs for the assigned clumps. Our data are primarily obtained with two different telescopes: the Herschel Space Observatory (HSO) and the James Clerk Maxwell Telescope (JCMT), but we also use archival data at 21 μm to constrain the SED fitting (see Fig 1).

The Herschel infrared GALactic plane survey (Hi-GAL) provided images of the entire galactic plane in 5 wavelengths (i.e. 70, 160, 250, 350, 500 μm). The JPS complements the Hi-GAL survey by adding additional data points (at 450 and 850 μm) to help further constrain the SED fits and more accurately determine the physical conditions in the star forming regions.

PROJECT: We will perform photometry on the a few of the clumps to extract the fluxes. Generally, the flux extraction is done via computer algorithms (i.e. CuTex (Molinary et al. 2011) & Fellwalker (Berry 2015)). For the data available for this project the flux extraction is already performed, however, the photometry will help us to understand the depth of the work done by previous studies.

Then, we will move on to the SED fitting part and perform the SED fitting for the assigned clumps. Given the presence of data at different waveband (see Fig 1) the SED fitting result will extract the physical condition of the star forming region.

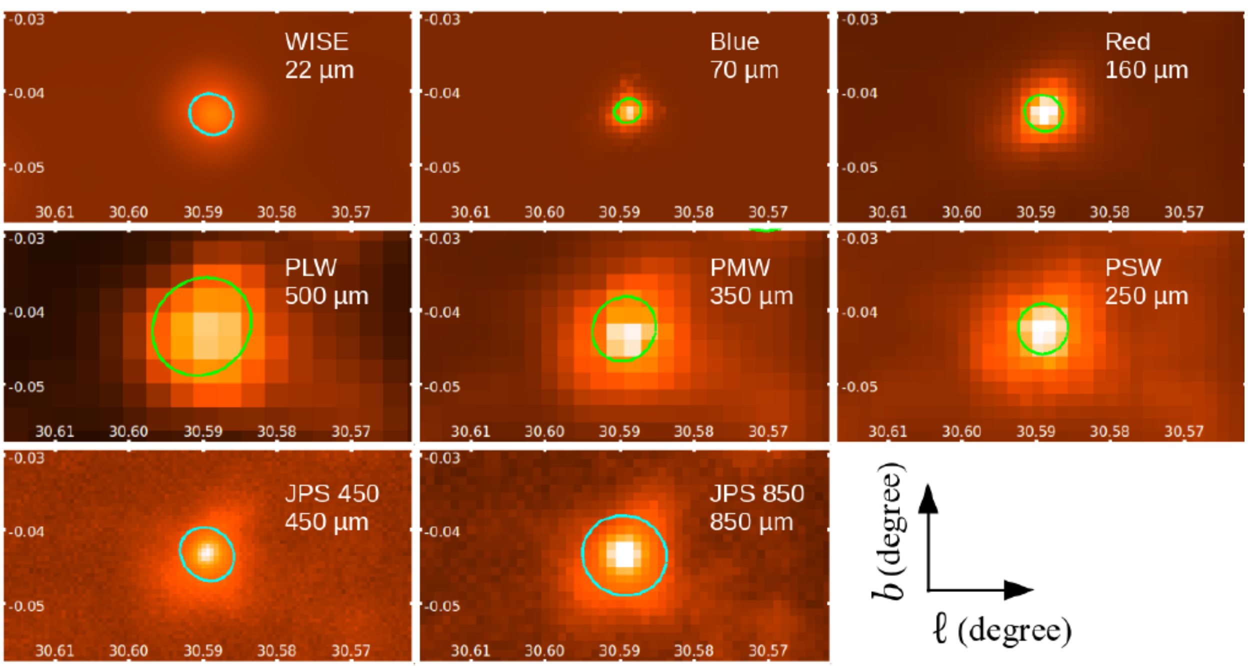

Figure 1: The image shows observation of the same clump at different wavebands

Things to do:

Week 1	- Get familiar with the basics of the star formation
Week 2	For data at $\mathrm{l} = 30°$ - Get familiar with the basics of the star formation - Get familiar with the basics of the radiative transfer equation, e.g. $I = I_{bg}e^{-\tau}$ - Software Installation, IDL & ds9
Week 3	For data at $\mathrm{l} = 30°$ - Get familiar with the basics of the SED, and the evolutionary stages of the star formation - Load data into ds9 and get comfortable with visualizing the data - Understand data & get familiar with Galactic coordinate system - Software Installation, IDL
Week 4	For data at $\mathrm{l} = 30°$ - Load Region file - Perform Photometry - Compare the results with the actual result already extracted via CuTex & FellWalker algorithm - Software Installation, IDL
Week 5	For data at $\mathrm{l} = 30°$ - Get familiar with the basics of the radiative transfer equation, e.g. $I = I_{bg}e^{-\tau}$ - Run the SED fitting algorithm - Comprehend the SED algorithm
Week 6	For data at $\mathrm{l} = 30°$ - Get familiar with the basics of the radiative transfer equation, e.g. $I = I_{bg}e^{-\tau}$ - Run the SED fitting algorithm - Comprehend the SED algorithm
Week 7	For data at $\mathrm{l} = 30°$ - Get familiar with the basics of the radiative transfer equation, e.g. $I = I_{bg}e^{-\tau}$ - Run the SED fitting algorithm - Comprehend the SED algorithm
Week 8	For data at $\mathrm{l} = 30°$ - Run the SED fitting algorithm - Comprehend the SED algorithm
Week 9	For data at $\mathrm{l} = 30°$ - Run the SED fitting algorithm - Comprehend the SED algorithm
Week 10	For data at $\mathrm{l} = 30°$ - Run the SED fitting algorithm - Comprehend the SED algorithm - Extract Mass Luminosity & temperature
Week 11-16	Generate the same result as above for data at $\mathrm{l} = 10°$
Week 17 - 21	Prepare your presentation
Week 22 - 24	Relax & Enjoy 😉