# Objective – 1-2 paragraphs

Topic: combine data from multiple telescopes to extract the temperature, mass and luminosity of the star forming region

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.

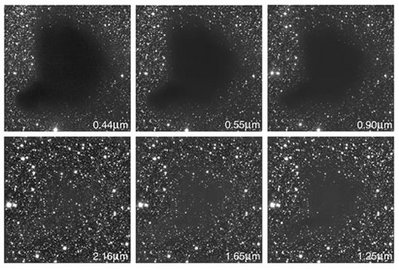
Then, we will move on to the SED fitting part and perform the SED fitting for the assigned clumps. Given the presence of data at different waveband (see Fig 1) the SED fitting result will extract the physical condition of the star forming region

# Theory

## Star Formation

People like to think of the space between the stars as being completely empty. However, it is composed of four things: matter, in the form of dust and gas; electromagnetic radiation; gravitational fields and magnetic fields [1].

This is known as the ‘**interstellar medium’** (ISM). It has a chemical composition of ~90% Hydrogen, ~10% Helium and only ~0.1% more massive elements [1]. ~99% of interstellar matter is gaseous and it has an average density of 0.1 atoms/cm­­­3 [1]. To give a point of reference, the air we breathe on Earth is about 2.7 x 1019 atoms/cm3 and the best vacuum we can create is still 1010 atoms/cm3.

**Interstellar dust** makes up approximately 1% of the material in the ISM. In size, it ranges from the size of a large molecule to ~300 nm across [1]. Don’t be fooled by its size, however, as it is extremely good at blocking out light. This is known as ‘interstellar extinction’. It best blocks out light which has a wavelength about the size of the dust grain, meaning short wavelengths are absorbed or scattered whereas long wavelengths pass through, uninhibited [4]. This effect is displayed in the following image, showing the cloud quite visible at 0.44 µm and almost invisible at 2.16 µm, suggesting a large number of the dust grains are around 0.44 µm in size.

<http://astronomy.swin.edu.au/cosmos/E/Extinction>

**Interstellar clouds** have an average temperature of ~100 Kelvin. They are composed of mostly neutral atomic Hydrogen [4]. They are relatively dense, at a density of 1 – 100 atoms/cm3 [1]. Only in the densest clouds can molecules exist; these are known as ‘**molecular clouds**’. They are approximately 10 Kelvin, cold and dense. They have a density of 100 – 1000 atoms/cm3 and they range between ½ a light year to 1000 light years in size. **Cold Dark Clouds** (CDCs) are where molecular clouds are formed; they contain both atomic and molecular gas and are a density and temperature intermediate between the atomic ISM and molecular clouds [2]. Only about ¼ of the mass of the ISM is in molecular form and most of it is found in **giant molecular clouds** (GMCs) [3]. These GMCs contain **clumps** which, in turn, contain cores and it is within these cores that a star is formed [5].

**Stellar nurseries** are known as the ‘cradles’ of star formation [1]. These interstellar clouds are massive enough to have self-gravity. If an interstellar cloud is massive, dense and cool enough, the self-gravity is enough to overpower the internal gas pressure pressing against it, and the cloud collapses under its own weight [6].

Because molecular clouds are never uniform, some areas collapse faster at an accelerated rate, due to the inverse square law of gravity [1]. Self-gravity becomes stronger in these areas and these are what form ‘**molecular cores**’. Due to the angular momentum of the cloud, it forms a flat, rotating disk, also known as an ‘**accretion disk**’ with a **protostar** at the center [1].

Within the protostar, gravitational energy is converted to thermal energy, increasing its temperature [1]. The protostar is 100x the size of the sun, with a surface area of tens of thousands of times larger making it 1000x more luminous. There are still no nuclear reactions yet.

The forces acting on the protostar are still relatively balanced; the hot-gas pressure outward roughly equals the self-gravity pulling inward [1]. This is constantly changing as material continuously falls onto the protostar. The increased gravitational pull increases the internal pressure. The increased gravity increases the internal pressure, and the protostar keeps growing hotter until, finally, Hydrogen fusion happens!

## Herschel and JCMT

The **Herschel Space Observatory** (Herschel) was set to discover information about the early universe. It detected radiation at far infrared and submillimeter wavelengths and was able to then observe dust in the ISM which was, otherwise, invisible. One of Herschel’s purposes was to observe interstellar clouds.

The Herschel infrared Galactic Plane Survey (Hi-GAL)

The **James Clerk Maxwell Telescope** (JCMT) is a ground-based telescope based at Mauna Kea Observatory in Hawaii, US [7]. It is the largest astronomical telescope in the world that is designed to operate in the submillimeter wavelength part of the spectrum. These instruments for detecting submillimeter radiation on the JCMT are known as the Submillimeter Common-User Bolometer Array (SCUBA).

The objective of the **JCMT Galactic Plane Survey** was to get a full survey of star-formation activity in the plane of the Galaxy which is observable from JCMT [2]. Two of the four main goals were ‘the star-forming content of molecular clouds’ and ‘Cold Dark Clouds and the formation of molecular clouds’. Arrays like SCUBA have made it possible to map the thermal emission of cold dust from dark clouds [4].

# Solution – 1-2 pages

## Work packages

How long?

What materials?

What is the outcome?

# SWOT – strengths, weaknesses, opportunities, threats

Strengths – what do we have here that allow this project to go well, i.e. Kianoosh, my skills, algorithm already written, flux already extracted

Weaknesses – things we’re lacking, i.e. my skills, unfamiliar with IDL, didn’t write algorithm, algorithm was written for linux – needs to be modified for windows

Opportunities – things that might help the project that might come externally, like you could work together on something – but there might not be any in this case. Could also be where to go next with the project

Threats – things that might screw the whole thing up

# References

[1] textbook at my house

[2] <https://www.eaobservatory.org/jcmt/science/legacy-survey/jps/>

[3] <https://arxiv.org/pdf/1001.2106.pdf>

[4]<https://arxiv.org/pdf/0705.3765.pdf>

[5] <https://arxiv.org/pdf/astro-ph/9902246.pdf>

[6] <https://royalsocietypublishing.org/doi/pdf/10.1098/rsta.1902.0012>

[7] <https://www.eaobservatory.org/jcmt/>

[8] <https://www.herschel.caltech.edu/>