ASTR 5470 Interstellar Medium Final Project

You will use actual data to estimate the physical properties of a region observed by the *Herschel Space Observatory*. You will also determine the necessary integration time necessary to obtain such data using both *Herschel* and *SOFIA*. Finally, you will write a short proposal to study a Bok Globule. The total number of possible points is 100: the first portion is worth 60 points, and the proposal on the Bok Globule is worth 40 points.

Please work on this independently. It is **due 5:00 pm on 13 December 2024**.

Supporting information:

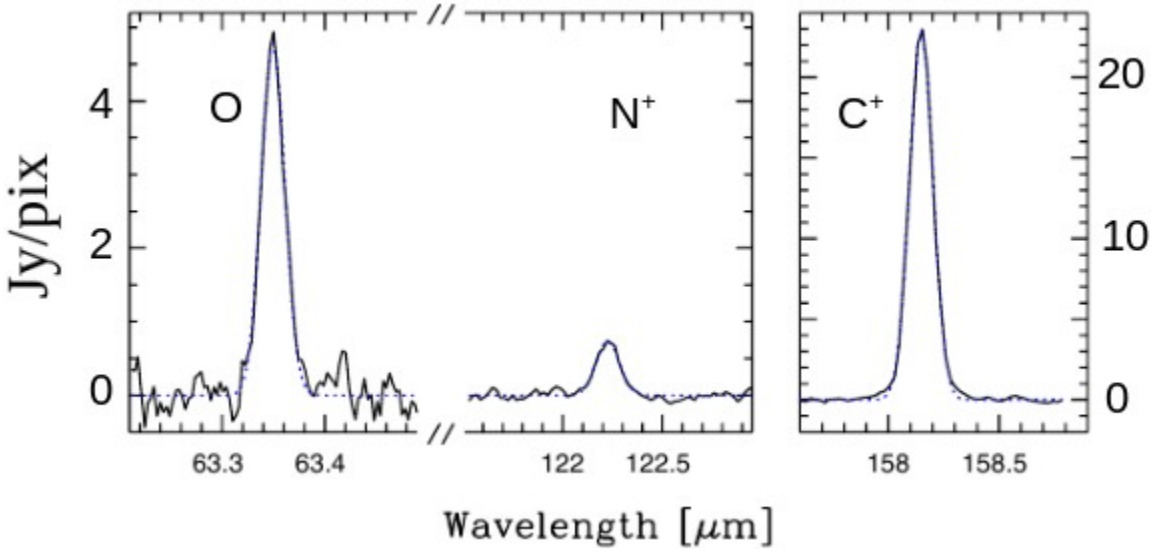
The extragalactic data in the figure below come from the PACS spectrometer aboard the *Herschel Space Observatory*. The left/middle/right is from O/N^+/C^+ extracted for 10" pixels.

The 24, 70, 160 and 250μm flux densities from a 40" diameter circular beam are 0.44, 6.35, 17.8, and 4.0 Jy, respectively. Assume that the source is much larger than the 40" beam size.

The "total infrared" continuum emission can be computed via Equation 4 of Dale et al. (2014):

$$L_{\rm TIR} = \zeta_1 \nu L_\nu(24\,\mu{\rm m}) + \zeta_2 \nu L_\nu(70\,\mu{\rm m}) + \zeta_3 \nu L_\nu(160\,\mu{\rm m})$$

where ζ_1=1.548, ζ_2=0.767, ζ_3=1.285 for z=0. There are a variety of tools available for estimating the desired physical characteristics, including the Tielens textbook and the *PDR Toolbox*.



Galaxy spectra

0. Sketch a full UV-optical-infrared-radio spectrum of a normal star-forming galaxy, and label the various components with the appropriate physical mechanisms.

Line fluxes

1. Estimate the integrated flux in W/m^2 for each line, per 10" pixel. Put results in a table.

Signal-to-Noise

2. Estimate the signal-to-noise (S/N) in the above [OI] line measurement. Add to your table.

Integration time with Herschel

3. Compute the requisite integration time using Herschel/PACS to produce the observed S/N for the [OI] line spectrum. See https://irsa.ipac.caltech.edu/data/Herschel/docs/nhsc/pacs/PACSInstrumentDescription.html

Integration time with PRIMA

4. What would be the corresponding integration time for the [OI] line using the high resolution spectrometer on PRIMA? See https://prima.ipac.caltech.edu/page/instruments

PDR properties

5a. Use the IR line and broadband data to infer the incident FUV intensity G_0 and the cloud density n.
5b. Estimate the gas temperature if the gas cooling entirely comes from C^+.
5c. Use the IR broadband data to estimate the dust temperature.
5d. What does this region most closely resemble, in terms of its physical properties: a reflection nebula, the Orion Bar, a planetary nebula, the nucleus of the Milky Way, or a starburst galaxy?

Report

6. (60 points) Write a brief (≤ 2 pages) report of your findings, including a detailed explanation of how you made all the estimates in Problems #1 through #5. This does not need to be typewritten, nor does it have to look like a formal "report".

Proposal

7. (40 points) Write a brief (≤ 3 pages) proposal how you would use the *Herschel Space Observatory* to measure the dust temperature for a newly-discovered, and presumably very cold, Bok Globule. Though you would essentially be breaking new territory with such a study, your only piece of data to support your proposal is that this Bok Globule has a 70μm flux density of 1.27 Jy. The proposal should be similar to what would be formally submitted to a Telescope Allocation Committee and include the following sections:

Scientific Motivation
Technical Plan
Figures, Tables, References (if applicable)
Observation Summary Table