The Interstellar Medium (ISM) is the gas and dust between the stars. Stars form from it, their winds and supernova enrich and replenish it. Temperatures in the ISM range from the very hot, \( > 10^6 \) K, to the very cold, \( < 10 \) K. Observed densities span an even wider dynamic range, from \( < 10^{-3} \) to \( > 10^6 \) particles per cubic centimeter. Even the highest densities, however, are more rarefied than the best vacuums currently attainable on Earth. Thus the ISM allows us to explore physical processes in unique environments. This course will discuss observations and theories of a wide range of ISM environments from pervasive diffuse, ionized gas to dense, molecular clouds.

The course website is [www.ifa.hawaii.edu/users/jpw/ism](http://www.ifa.hawaii.edu/users/jpw/ism) where I will post lectures and papers for discussion. I also list several textbooks and online lecture notes that I refer to for derivations and more detail than I will give in the lectures.

The classroom will be used not solely for lectures but also for interactive discussions. Each student will, at different times, present their solutions to a problem set and discuss an area of current research related to the lectures. The discussions and problems sets will account for 60% of the final grade.

In addition, each student will carry out a small research project. These require analyzing (reduced) datasets and/or carrying out specific calculations. Many of the projects are based on published work and the aim is to show the application of various physical concepts introduced in class. Each student will write a short, ApJ Letter style paper by April 27th. The last 2 classes will be devoted to student presentations of their project. The paper and presentation will account for 40% of the final grade.
Syllabus

1. Some fundamentals
Statistical mechanics
The non-equilibrium ISM
Radiative transfer
Fluid dynamics

2. Dust
Reddening and extinction
Mie theory
Temperature
Absorption and emission

3. Ionized regions
Strömgren sphere
Bremsstrahlung and synchrotron radiation
Ultra-compact HII regions, super star clusters
The 2-level system
The 3-level system

4. Atomic regions
The 21cm line
Equivalent width

5. Heating and cooling
Heating and cooling mechanisms
The 2-phase ISM
The 3-phase ISM
The intergalactic medium

6. Molecules
Vibrational and rotation states
Molecular clouds
Astrochemistry
Photon dominated regions
The extragalactic context

7. Dynamics
The Jeans’ mass (and swindle)
Shocks
Expanding supernova remnants
Star formation

8. The circumstellar medium
A short primer on disks and planet formation