Star Formation Theory-- Topics

ASTR 541

Seminar in Theoretical Astrophysics

- **Giant Molecular Clouds (GMCs) -- structure and turbulent properties**
  - Cloud properties and observed scaling laws
  - MHD turbulence -- power spectra of **v** and **B** from simulations
  - Turbulent dissipation and driving
  - Density structure -- PDFs and correlations
  - Observational diagnostics of turbulence and magnetic fields in GMCs

- **GMCs – microphysics**
  - Heating and cooling processes for gas and grains
  - Molecule formation and dissociation
  - PDR solutions
  - Radio and IR diagnostics
  - Ambipolar diffusion, C shocks

- **Low-mass prestellar and protostellar cores: formation and structure**
  - Identification of cores in molecular-line and continuum surveys; inferring ages
  - Formation mechanisms and connection to environment
  - Bonnor-Ebert spheres
  - Magnetized equilibria; ambipolar diffusion

- **Collapse of low-mass cores**
  - Isothermal unmagnetized collapse: Larson-Penston solution, Shu solution, generalized solutions
  - Observational diagnostics of collapse
  - Effects of magnetic fields
  - Effects of rotation
  - Disk formation and magnetic braking

- **Protostars and pre-main sequence stellar evolution**
  - First hydrostatic core
  - Deuterium burning
  - Stellar birthline
  - Hayashi and Henyey tracks

- **T Tauri systems -- radiation diagnostics**
  - Spectral Energy Distributions (SEDs): star, disk, and envelope contributions
  - Inferred vertical structure of disks
  - Accretion shock diagnostics
  - Disk diagnostics from line emission

- **Winds, jets, and outflows from Young Stellar Objects (YSOs)**
  - Magnetohydrodynamic (MHD) winds: disk winds, X-winds; acceleration and collimation
  - Magnetosphere-disk interactions and flow onto the star
  - Molecular outflows from wind/ambient interactions
  - Herbig-Haro objects

- **Protostellar disks -- accretion processes**
  - Thermal/ionization structure of disks; dead zones and layered accretion
  - Magnetorotational instability (MRI) in partially-ionized disks -- resistivity, Hall effect, ambipolar diffusion
  - Angular momentum transport via self-gravitating instabilities
  - Spatially-variable accretion rates and the FU Ori outburst phenomenon
  - Evolutionary models

- **Binary star formation**
  - Statistics of binaries
  - Formation via capture
  - Formation via fragmentation of rotating core or disk
  - Accretion in binary systems

- **Protostellar disks -- gas/grain dynamics**
  - Regimes of grain/gas aerodynamic drag laws
  - Vertical settling of dust
  - Differential mass loading and Kelvin-Helmholz instabilities
  - Gravitational instabilities in dust-loaded layers (Goldreich/Ward)
  - Gas-dust streaming instability
  - Particle concentration in gas disk structures (pressure maxima, vortices)

- **Planet formation -- overview in the star formation context**
  - Planetisimal formation -- collisional agglomeration of > meter-sized bodies
  - Runaway growth and oligarchic growth stages
  - Gas giants -- core accretion vs. gravitational instability models
  - Planet migration -- Type I and Type II
  - Planet-planet scattering

- **Disk clearing around low-mass stars**
  - Photoevaporation by external radiation (EUV)
  - Photoevaporation by a central object (FUV, X-ray)
  - Gap opening and evolution to transition disks

- **The Initial Mass Function (IMF)**
  - Relation between observed IMFs and Core Mass Functions (CMFs)
  - Winds/outflows and core-to-star conversion efficiency
  - Theories of gravoturbulent fragmentation of GMCs into cores -- physical dependence, numerical simulations
  - Competitive accretion theories

- **Star cluster formation**
  - Fragmentation of massive, turbulent cores
  - Feedback effects in clustered environments
  - Stellar mass segregation
  - Small-N dynamical interactions; sub-cluster merging
  - Gas expulsion and post-expulsion dynamical relaxation

- **High-mass star formation**
  - IRDCs; progenitor structures for high-mass stars
  - Effects of radiation pressure on dusty envelopes/accretion flows
  - Outflows from high-mass stars
  - Compact HII regions

- **Destruction of GMCs**
  - HII region expansion -- classical solutions
  - Blister HII regions and champagne flows
  - Effects of radiation pressure, stellar winds, supernovae
  - Cloud lifetimes

- **Star formation on galactic scales**
  - Kennicutt-Schmidt and other empirical laws
  - GMC formation mechanisms -- collisional agglomeration, self-gravitating instability, effects of spiral structure
  - Star formation efficiency in GMCs
  - Self-regulation of star formation via feedback -- ISM equilibrium models

- **Primordial star formation**
  - H_2 formation under high-z conditions
  - Cooling of metal-free and metal-poor gas
  - Stages of evolution for primordial prestellar ``cores''
  - Feedback effects in primordial star formation
  - Fragmentation in primordial star formation