Monte-Carlo Models of Accretion Disks Around Young Stars in the Orion Nebula

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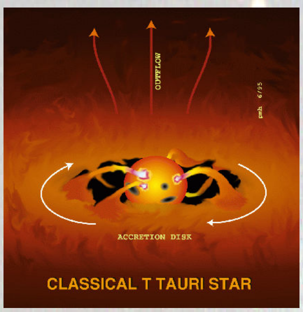
Abstract

Current theory suggests that the accretion disks around classical T-Tauri stars regulate the spins of these stars, by way of the magnetic field lines. These field lines extend from the star into the accretion disk, and in effect "locking" the angular velocity of the star to that of the material at the inner edge of the disk (the truncation radius). This disk shows up as an IR excess in the spectral energy distribution (SED) emitted by the star. The truncation radius of the disk can be determined from the observed SED. According to theory, this truncation radius can be a key parameter in the regulation of the angular momentum evolution of the star.

We are currently using a Monte-Carlo code to model the SEDs of some 600 young stars in the Orion Nebula. By comparing these models to upcoming observations of these young stars, we will test whether the truncation radii of the stars are consistent with that predicted by theory.

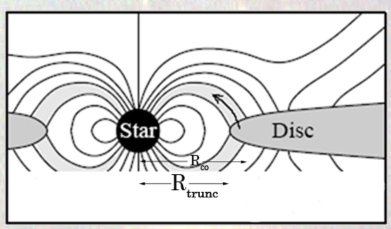
Motivation: The Angular Momentum Problem of Star Formation



- As a young star collapses due to gravity, its spin should increase due to conservation of angular momentum.
- However, most young stars are observed to rotate relatively slowly. What happens to the angular momentum?
- It is thought that the accretion disks around Classical T-Tauri stars may regulate their spin.

"Disk-Locking": A Possible Solution

- Magnetic field lines connect the accretion disk to the star.
- The balance between the magnetic field strength and the accretion pressure determine the size of the truncation radius (R_{trunc}).



- The star is forced to co-rotate with disk material at $R_{trunc.}$
  → $R_{trunc} \approx R_{co}$
- Thus, R_{trunc} determines the rotation period of the star. For example, larger R_{trunc} produces slower rotation

Study Objectives and Sample

Objectives

Model the spectral energy distributions (SEDs) of a large sample of young stars to determine whether they possess disks with $R_{trunc} \approx R_{co}$ as predicted by theory.

Sample

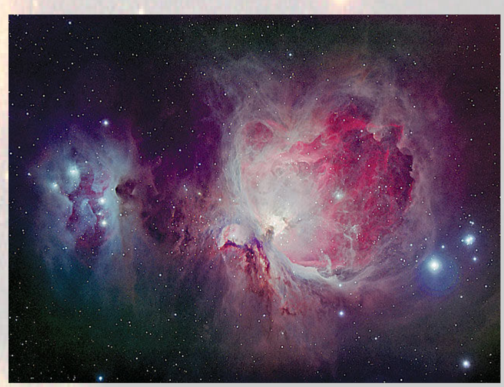
A sample of 600 hundred stars was chosen for this study, all selected from the Orion Nebula (M42) ,with the following known properties:

- rotation period
- mass

R_{trunc}

- luminosity
- effective temperature

Stellar SED



SED Modeling Code: TTSRE (T Tauri Star Radiative Equilibrium)

written by Whitney & Wood

What is TTSRE?

A program that calculates temperature structure of disk by solving for radiative equilibrium. Runs models and produces spectral energy distributions (SEDs) unique to each star.

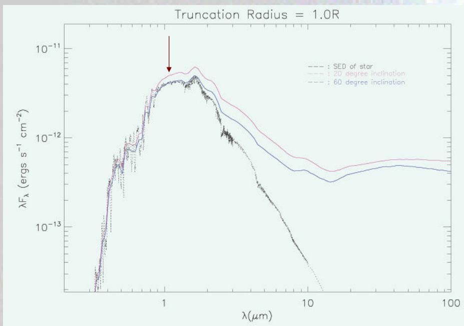
Models for each star the trajectory and wavelength of photons “emitted” by star, and monitors their interactions with the accretion disk.

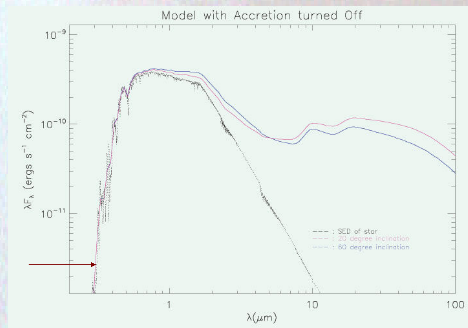
What inputs does TTSRE require?

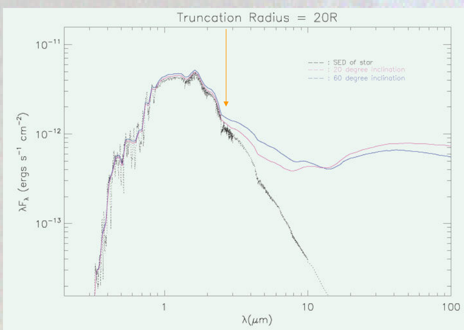
TTSRE needs to know different characteristics about each star to run models and produce SEDs:

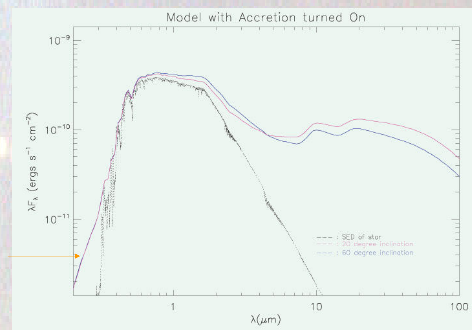
- Stellar parameters: mass, temperature, luminosity
- Disk parameters: using the known rotation period, truncation radius of the (flared) accretion disk can be calculated assuming $R_{trunc} = R_{co}$.

Example Model SEDs





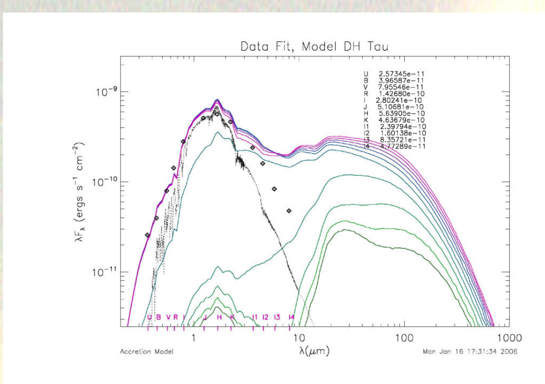




Models with varying R_{trunc}. Note the excess (→) at about 0.9 microns when R_{trunc} is small. When R_{trunc} is large, there is still an excess, but at larger wavelengths; ≈ 3-4 microns (→).

Models with accretion turned off and on. The arrow (→) shows the UV excess when accretion is turned on, while (→) shows no UV excess when accretion is turned off.

Next Steps?



Model SEDs have been produced with and without accretion for all stars in our sample.

These model SEDs will be compared with optical and IR data from HST & Spitzer.

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