Observational ISM and Star Formation

<u>This Class (Lecture 9):</u>

Core Collapse &
Kristopher Czaja/William Kormos

<u>Next Class:</u>

More Collapse &
Hsin-Lun Kuo/Kristen Samuels

Music: *Across the Universe* – Beatles

Astro-ph

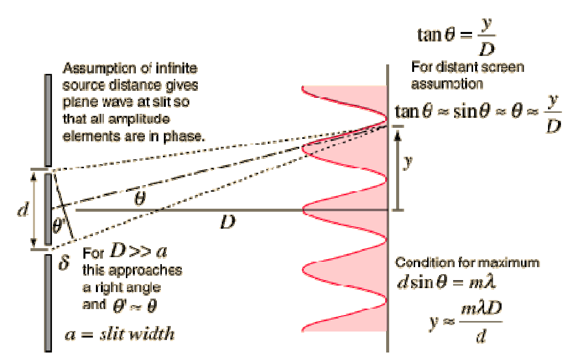
1. Pre-main sequence spectroscopic binaries suitable for VLTI observations
   (E. W. Guenther, M. Esposito, R. Mundt, E. Covino, J. M. Alcala, F. Cusano, B. Stecklum)
   - Masses of young stars are almost always estimated only from evolutionary tracks, which vary from group to group.
     - So masses of young stars are only roughly known
   - With VLTI can measure rotation of close binary system
     - Measure masses directly
   - Compiled a list of appropriate sources

http://arxiv.org/abs/astro-ph/0702268

Outline

- Interferometry in 10 mins?
- Isothermal spheres
- Bonner-Ebert Spheres

The Double Slit Experiment

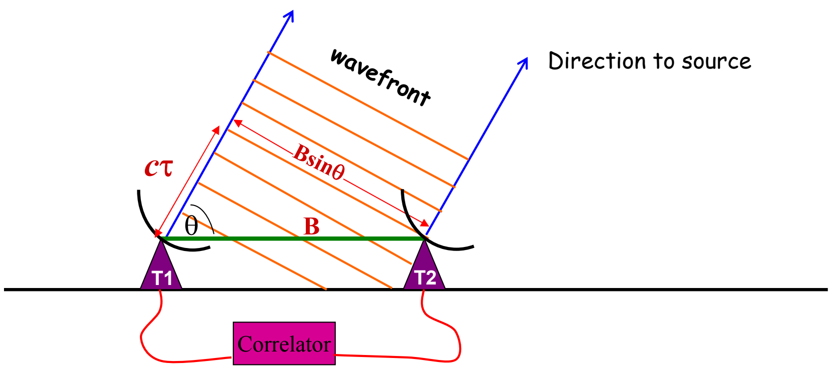


http://www.colorado.edu/physics/2000/schroedinger/two-slit2.html

http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/slits.html

Basic Concepts

- Similarly, an interferometer measures coherence in the electric field between pairs of antennas (baselines).

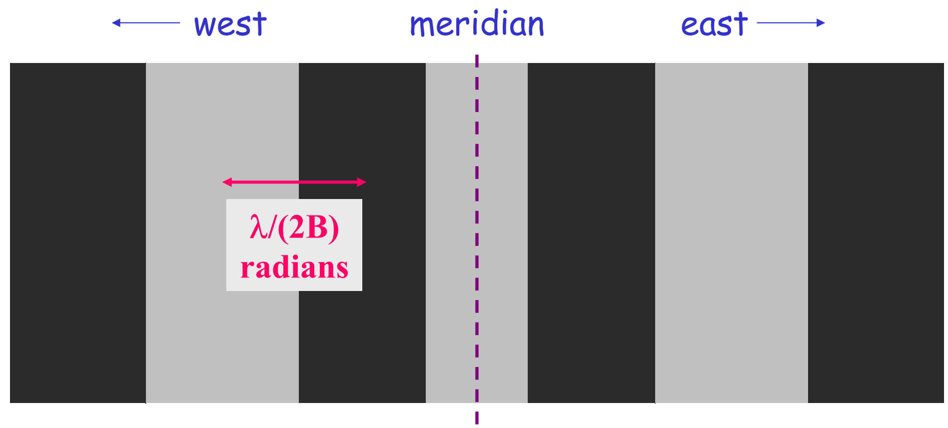


- Because of the geometric path difference cτ, the incoming wavefront arrives at each antenna at a different phase.

(courtesy Ray Norris)

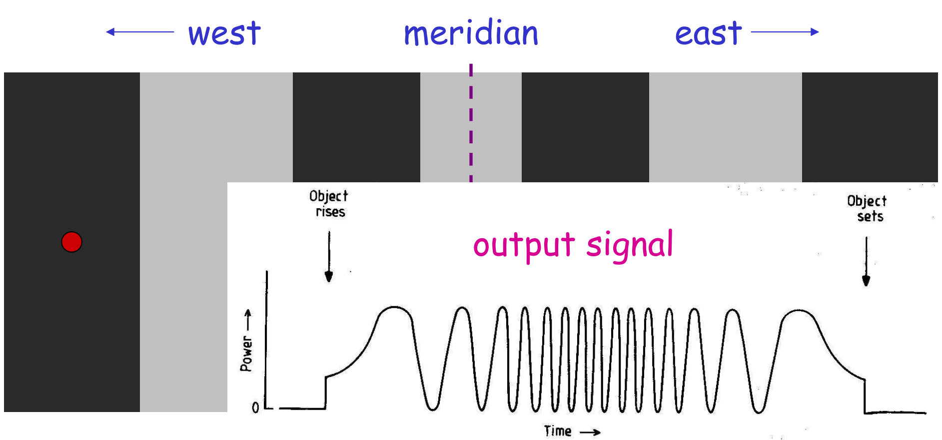
Fringe Concepts

The angular resolution of the interferometer is given by the fringe half-spacing λ/(2B).



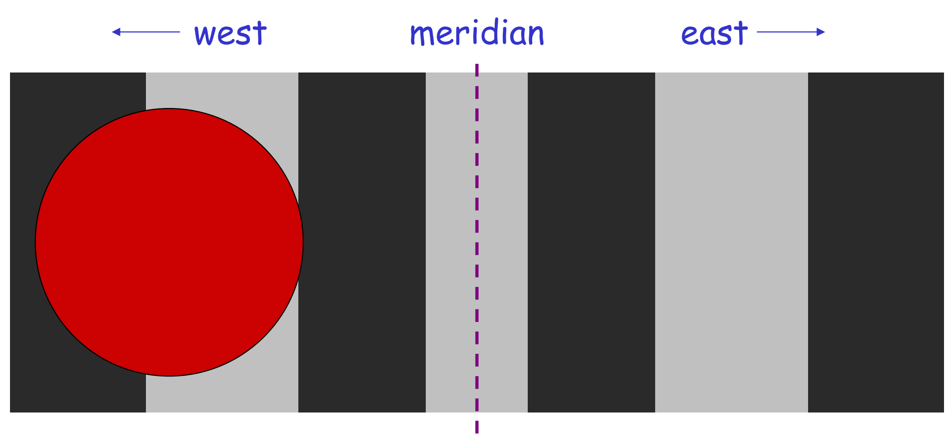
Basic Concepts

If the source is very small compared to the fringe half-spacing λ/(2B), we say it is unresolved. The output signal is just the fringe pattern, and the source structure cannot be determined.

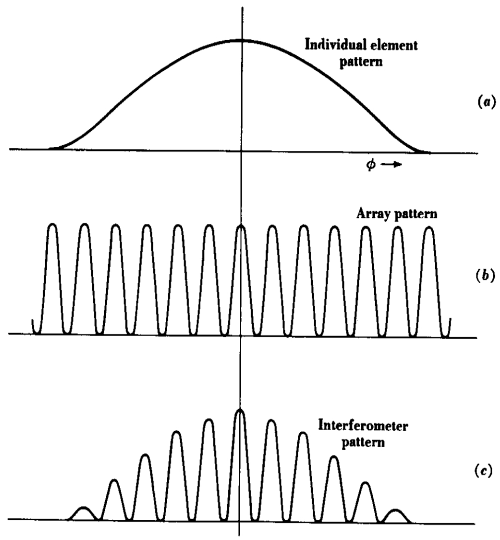


Basic Concepts

If the source is large enough to span both a peak and a trough in the fringe pattern, the output signal is nearly constant. The source is over-resolved or “resolved out”, and its structure poorly determined.



Fringes on the Sky

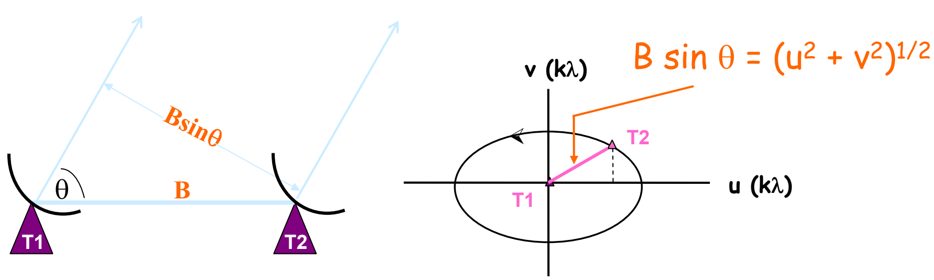


Fringes

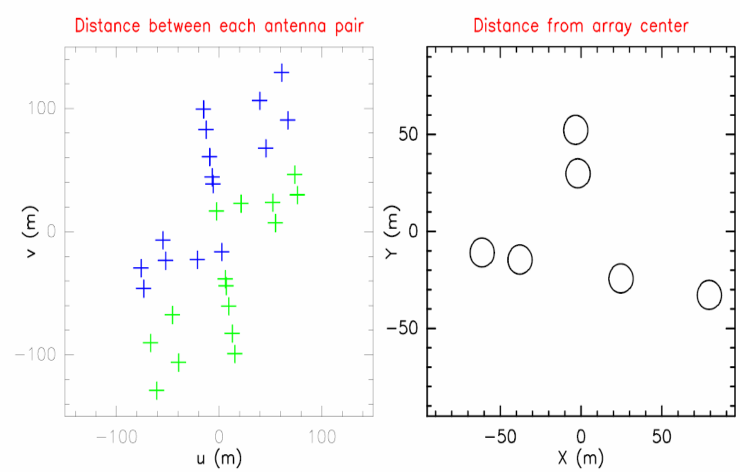
- By measuring the fringe peaks and valleys you are actually measuring the Fourier Transform of the sky brightness.
  - Also see, the van Citter-Zernike theorem
- By tracking a source, one gets multiple antenna separation, which allows for measurement of FT components of multiple orientations.
  - Array appears to rotate from point of view of sources
- The projection of a baseline onto the plane normal to the source direction defines a vector in (u,v) space, measured in wavelength units (i.e. kλ).

Aperture Synthesis

- As the source moves across the sky (due to Earth's rotation), the baseline vector traces part of an ellipse in the (u,v) plane.



Creating an Image



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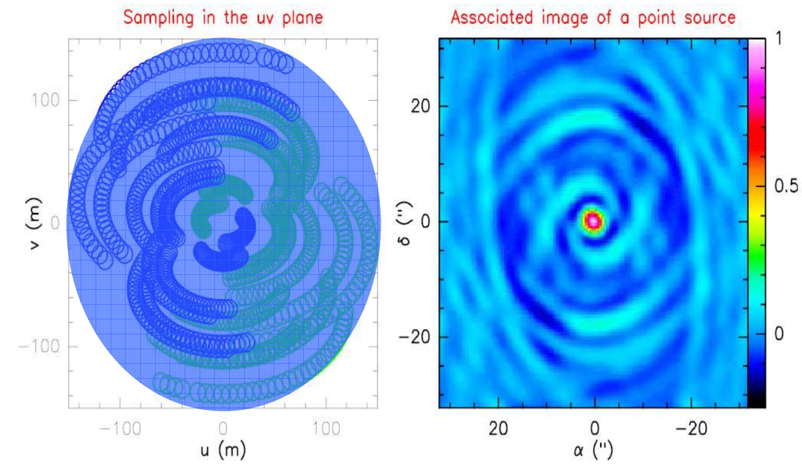
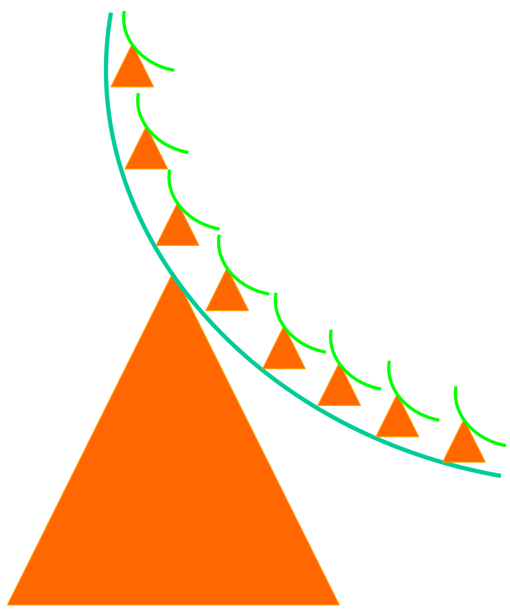


Aperture Synthesis

Hence the term "aperture synthesis"!



Isothermal Spheres

- Most of the early work is done assuming
  - Spherical clouds
  - Isothermal clouds
    - Not a bad assumption for dense, starless cores
- Use hydrostatic equilibrium and EOS of ideal isothermal gas, one gets the dimensionless isothermal Lane-Emden equation

$$\frac{1}{\zeta^2}\frac{d}{d\zeta}\left(\zeta^2\frac{d\psi}{d\zeta}\right)=\exp(-\psi)$$

Isothermal Spheres

$$\frac{1}{\zeta^2}\frac{d}{d\zeta}\left(\zeta^2\frac{d\psi}{d\zeta}\right)=\exp(-\psi)$$

Dimensionless radius

Dimensionless density

$$\zeta \equiv \left(\frac{4\pi G\rho_c}{c_s^2}\right)^{1/2} r$$

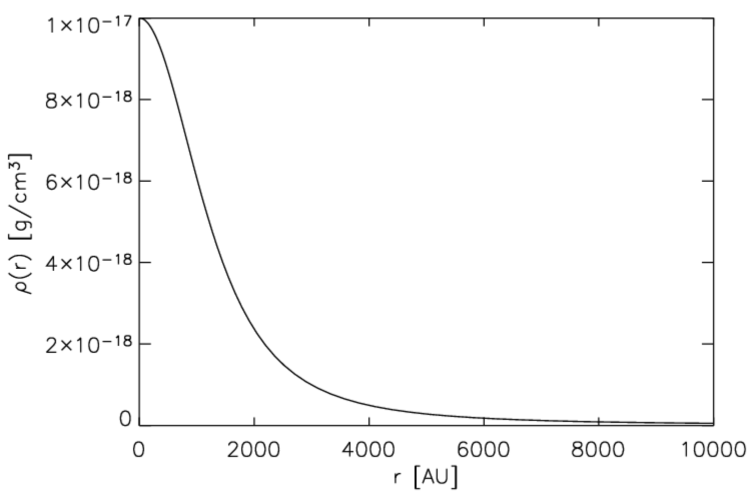
$$\rho(r)=\rho_c\exp(-\psi)$$

Lane-Emden: Boundaries

Use Boundary Conditions:

$$\psi(0)=0 \qquad \left.\frac{d\psi(\xi)}{d\xi}\right|_{\xi=0}=0$$

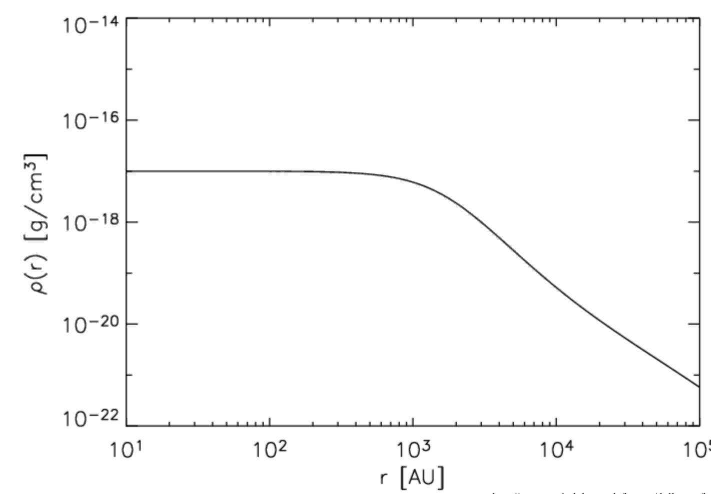
One Solution: Bonner-Ebert Sphere



http://www.mpia-hd.mpg.de/homes/dullemon/lectures/starplanet/index.html

One Solution: Bonner-Ebert Sphere

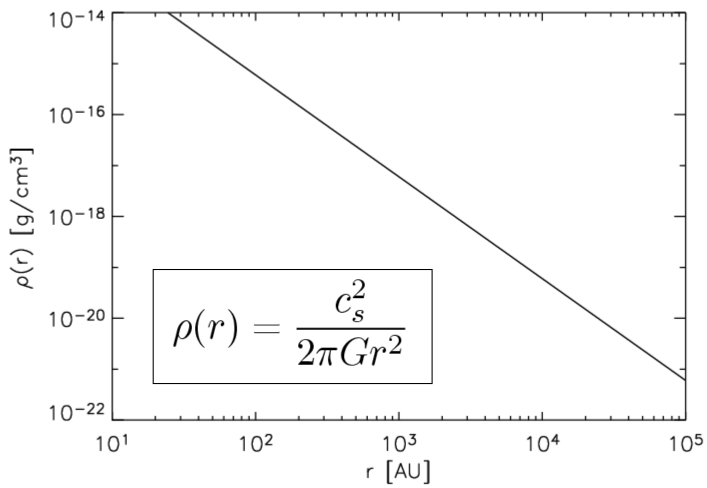
Plotted logarithmically (which we will usually do from now on)



http://www.mpia-hd.mpg.de/homes/dullemon/lectures/starplanet/index.html

Another Solution: Singular Isothermal Sphere

Limiting solution

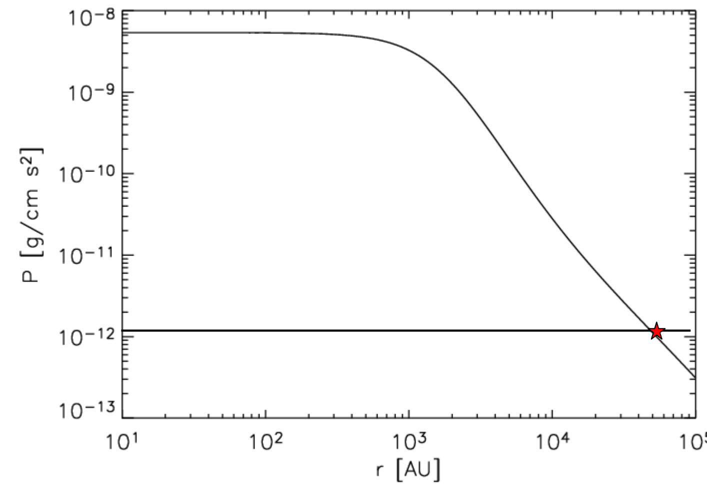


Hydrostatic self-gravitating spheres

Boundary condition:

Pressure at outer edge = pressure of GMC

sets the density at the edge, ρ_o

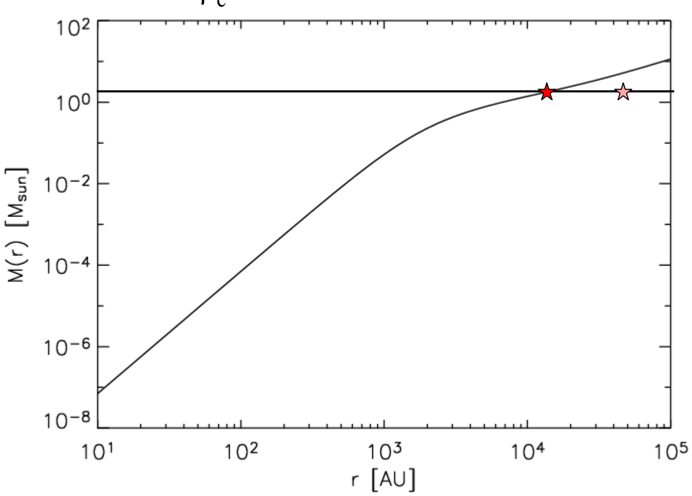


Hydrostatic self-gravitating spheres

Another boundary condition:

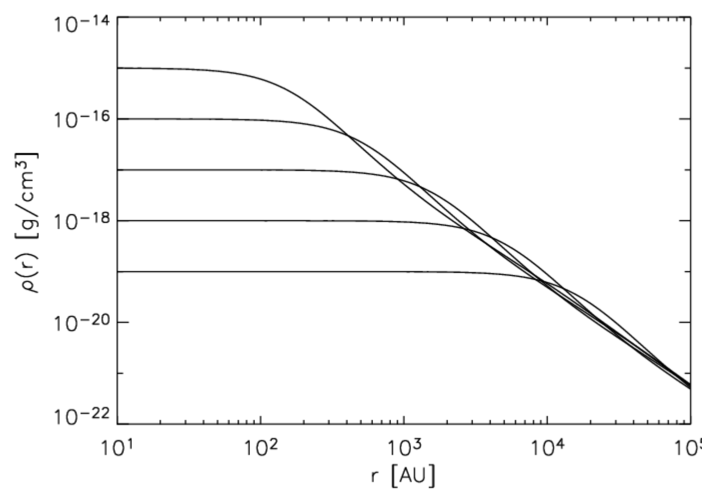
Mass of clump: one too many BC

That means ρ_c is determined



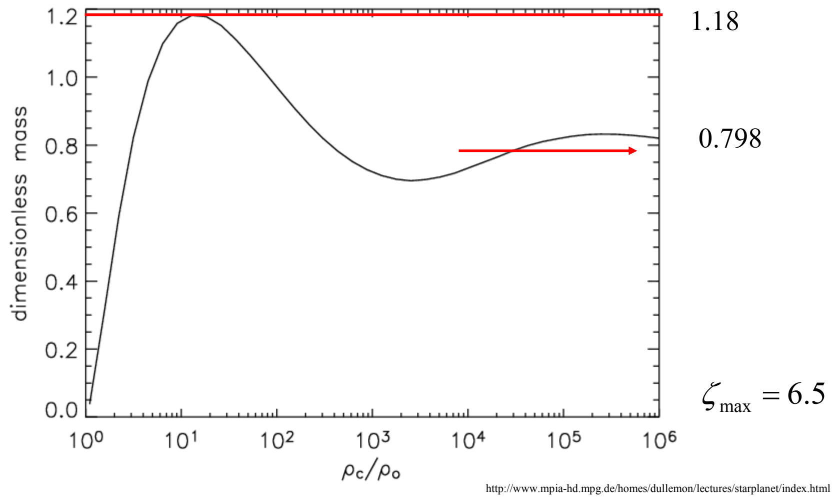
One Solution: Bonner-Ebert Sphere

Different starting ρ_c : a family of solutions



One Solution: Bonner-Ebert Sphere

Can make a dimensionless mass to the solution.
Many modes of instability.



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