

# DARA Unit 1 - Star & Planet Formation

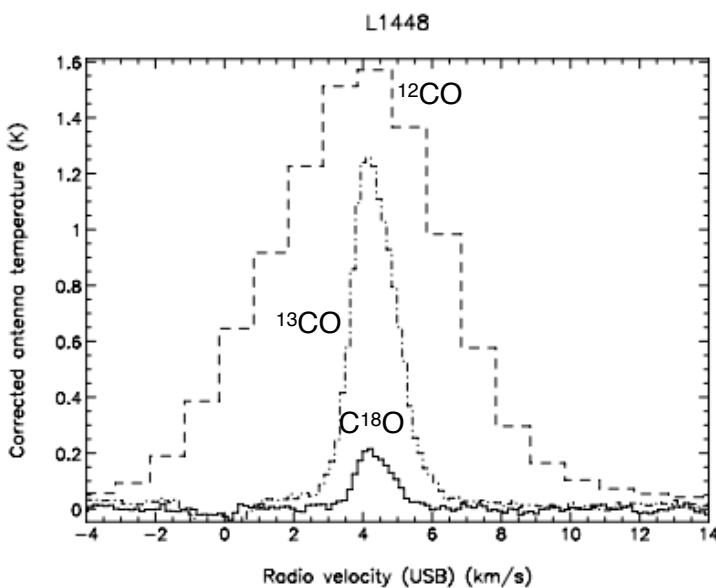
## Workshop 1 - Questions

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### 1) The velocity of molecules in a molecular cloud

- a) A typical molecular cloud has a temperature of  $\sim 10$  K. Compute the velocity of CO molecules in this cloud.

*Hint: this can be derived by equating the thermal energy with the kinetic energy and rearranging for velocity. This expression is provided in lecture 1.*



- b) The figure shows rotational line transitions of CO molecules observed towards the L1448 molecular cloud. Compare the velocity calculated in part a) with the velocity widths of the spectral lines in the figure. What does this tell you about this molecular cloud?

*Hint: we discussed observed linewidths versus thermal linewidths in lecture 1.*

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### 2) The Jeans mass

The expression for the Jeans mass,  $M_J$ , is

$$M_J = \left( \frac{1}{\mu m_H} \right)^2 \left( \frac{5kT}{G} \right)^{3/2} \left( \frac{3}{4\pi n} \right)^{1/2}$$

where  $\mu$  is the mean molecular weight of the gas,  $m_H$  is the atomic mass unit,  $k$  is Boltzmann's constant,  $T$  is gas temperature,  $G$  is the gravitational constant, and  $n$  is the gas number density.

- a) What is the physical significance of the Jeans mass?
  - b) Discuss the effect on the value of the Jeans mass when each variable ( $T$ ,  $n$ , and  $\mu$ ) in this expression is changed.
  - c) Evaluate the Jeans mass in units of solar masses for a typical molecular cloud with a gas temperature of 10 K and a gas number density of  $10^{10} \text{ m}^{-3}$ .
  - d) Comment on the possibility of forming a Sun-like star from such a cloud bearing in mind the result of part c).
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### 3) The formation of low-mass stars

When a gas cloud collapses, physics tells us that the temperature of the cloud should increase. However, this is not necessarily what is observed. It has been found that the cloud temperature stays constant during the initial stages of collapse under gravity (generally, it increases later).

- a) Discuss a potential mechanism for the cloud to stay the same temperature (i.e. to stay isothermal).
- b) Discuss the implications of such an 'isothermal collapse' for star formation.

*Hint: consider the expression for the Jeans mass given in Q2 for the case that the temperature stays constant.*

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