

Due Date: Oct. 5

## ASTR 202 Laboratory Exercise on The Formation of Sun-Like Stars

To receive full credit you must completely answer each question and show all work.

**Purpose:** To gain a better knowledge of the star formation process.

### 1 Star Formation Rate

You are a member of an alien race located on a planet at the outer edge of a spiral galaxy. The galaxy is 40,000 ly in diameter. From a study of the Doppler shifted emission from distant stars, you estimate your planetary system is orbiting the galaxy at 150 km/s.

a) What is the mass of your galaxy? State the answer in grams (gm) and solar masses ( $M_{\odot}$ ).

Hint:  $1 \text{ ly} = 1 \times 10^{18} \text{ cm}$

$1 M_{\odot} = 2 \times 10^{33} \text{ gm}$

$G = 6.67 \times 10^{-8} \text{ dyne cm}^2 \text{ gm}^{-2}$

$$(1 \text{ dyne} = 1 \frac{\text{gm cm}}{\text{sec}^2})$$

b) Assuming the vast majority of stars have a mass of  $0.4 M_{\odot}$ , approximately how many stars are in your galaxy?

c) If your galaxy is  $10^{10}$  years old, what is the average rate of star formation?

### 2 Giant Molecular Clouds

A giant molecular cloud is shaped like a sphere and has a diameter of 100 ly. The density of the cloud is  $\sim 10^3$  molecules/cm<sup>3</sup>.

a) What is the mass of the cloud?

Hint: volume of a sphere =  $V = \frac{4}{3}\pi r^3$ , where  $r$  is the cloud radius.

mass = volume  $\times$  density

mass of a single  $\text{H}_2$  molecule =  $3.5 \times 10^{-24} \text{ gm}$

b) What is the cloud's mass in  $M_{\odot}$ ?

c) If 25% of the cloud's mass is transformed into  $0.4 M_{\odot}$  stars, how many stars will the cloud produce?

### 3 Timescales

a) The star formation process takes about 10 million years to go from a diffuse interstellar cloud to a star with a planetary system. Stars like our sun exist about 10 billion years. What percentage of a star's life is spent in the formation process? Assume the average person lives to be 100 yrs. What percent of his/her lifespan is spent in formation?

b) Astronomers believe the molecular outflows from young stars "turn-on" just after the star forms out of the parent cloud. So, the age of a molecular outflow is a good indicator of the age of the star that drives it. Attached is a contour map of the central region of the Rho Ophiuchi molecular cloud made with a 30 m diameter mm/submm telescope. The contours associated with a molecular outflow from a young star (VLA1623) are highlighted. Assuming 1 cm on the map corresponds to  $3 \times 10^{16}$  cm, measure the distance from VLA1623 to the end of one of the molecular jets. The velocity of the gas in the jets is 10 km/s. How old is the molecular outflow in seconds and years?

#### 4 Planetary Systems

Over the past few years a number of planets have been found around other stars. Describe in words and pictures the technique used to find them.

$M_{ce} \leq 1 M_{\odot}$   
 $T_d \leq 20K$

### Low Mass Star Formation

