Exam 1 – Essays 1, 2, & 3 graded by Randi

- **Point divisions are estimates, final grade was determined by apparent understanding.**

Essay 1:
7 pts – proton-proton chain/nuclear potential energy
Full points were only given if you described all three steps:
$p + p \rightarrow d + e^+ + \square$
$d + p \rightarrow {}^3He + \square$
${}^3He + {}^3He \rightarrow {}^4He + 2p$
You also needed to describe that nuclear potential energy is released, drawing or describing the graph of potential energy vs. separation with the "hill" counts.

6 pts – 10^7 K is temperature needed to overcome barrier of electromagnetic force, describing that the protons repel and so they need a high temperature, which gives them high speeds

7 pts – Star forming regions contract by gravity, but emission of photons in the radio and infrared from dust and molecules slows this process. When the density is high enough, those photons get trapped in the cloud, raising the temperature until 10^7 K is reached.

➔ Almost no one included the full p-p chain so very few got full credit, however, most points of the 7 were given if you at least included the first reaction. Very few of you included the dust/molecule cooling in the third part, so again, few got full credit for that.

Essay 2:
10 pts – pick a value of R_* and describe that R_* is the number of stars in the galaxy divided by the age of the galaxy

3 pts – including relevant numbers
v=250 km/s
R=25000 ly
$M_{gal}=10^{11}$ solar masses
$M_{gal}=1.6x10^{11}$ solar masses (after correction for stars outside sun's orbit)
$M_{ave}=0.4$ solar masses (average mass of a star)
$N_*=4x10^{11}$ stars
$t_{gal}=10^{10}$ years

3 pts - for explaining how we get N_*; equations were not necessary, but if you didn't use them you must have described in words sufficiently that it was clear you fully understood what was going on

kinetic energy = ½ potential energy

$$\frac{1}{2}M_{sun}v^2 = \frac{1}{2}\frac{GM_{sun}M_{gal}}{R_{gal}} \Rightarrow M_{gal} = \frac{R_{gal}v^2}{G} \Rightarrow N_* = \frac{M_{gal}}{m_{ave}}$$

4 pts – listing the assumptions in this calculation

- This calculation is for an average rate of star formation. This assumes star formation is constant, while many astronomers believe it occurs in bursts.
- This calculation does not take into account the massive stars that have already died. We're assuming all the mass of the galaxy lies in stars and neglecting the interstellar matter ejected from those dead stars.

➔ Essay 2 was the one that most people got full points on, from essays 1, 2, & 3. If you included everything here, you got 20 points.

Essay 3:

7 pts – You needed to mention all three of the following:

- Disks are found around nearly all young stars
- Roughly 200 planets have been discovered so far (numbers between 200 – 300 were accepted)
- Most planets are large and Jupiter-like, some orbit very close to their stars. This is an effect of our method for finding them, so it doesn't mean all planetary systems are like that.

13 pts – State *your* value for f_p and *why* you chose it. The range of acceptable values for f_p is between 0.05 (updated in class from the book) and 1. If you picked a number outside those limits, then you did not get full credit. Most of the credit for this part was given for including reasoning that supports your answer and makes sense.

➔ Most people did not get full credit for essay 3 because there were inconsistencies or confusions in their reasoning behind f_p.