MONASH University

School of Physics and Astronomy
ASP4000 – 2017
Due: before Class 4

ASP4000 Stars

Homework Set 1

Perform all calculations and provide results using cgs units or solar units where appropriate. Final results for long time scales may be converted to "yr".

1. **Energy Generation**

   (a) **Compute the specific energy generation rate of the Sun as a whole.**

   [2 marks]

   (b) **Assume a human of weight 100 kg has a "luminosity" of 100 W. Compute the specific energy generation rate of a this human.**

   [2 marks]

   (c) **Compute the ratio of the result from (b) relative to (a). Comment on the result.**

   [1 mark]

   (d) **Use the values from above to compute the Eddington Luminosity of a human.** Note that "standard" Eddington luminosity is defined by (non-relativistic) electron scattering opacity only. For simplicity, assume a human consists 100 % water and and can be approximated as a sphere.

   [4 marks]

   (e) **From the assumptions provided above, compute the effective temperature of a human. Discuss and explain the result.**

   [4 marks]

   (f) In practise, in particular considering the temperatures involved, humans do not consist of fully ionised gases, but rather have atoms and complex molecules. These have much higher opacities at the relevant temperature of a human. **Assuming an opacity of just $10\,\mathrm{cm^2\,g^{-1}}$, compute the "effective" Eddington luminosity. Compare with the actual energy output of a human as provided above. What does this result imply and how can it be explained?**

[4 marks]

(g) **Modern CPUs.** Modern micoprocessors have now reached a "gate width" of 11 nm. Assume this corresponds to the thickness of the "active" layer that contains micoprocessors and density of silicon of $2.33\,\mathrm{g/cm^3}$. The typical die size is about $100\,\mathrm{mm^2}$ and they have a power up about 100 W.
What is the specific energy generation rate of the active layer?

[4 marks]

(h) **How long does it take for the "active" layer of the CPU to release as much energy as its rest mass?**

[4 marks]

(i) **What happens when you run your computer that long – having converted the rest mass of the "active" layer into energy?**

[4 marks]

(j) Dimensional Analysis
What is the specific energy generation rate corresponding to an element of mass radiating away its entire rest mass in 1 s?
Consider Units.

[2 marks]

(k) Assume a characteristic chemical energy content of 10 eV per nucleon for chemical burning, and a characteristic nuclear energy content of 6 MeV per nucleon for complete nuclear burning. Convince yourself that these numbers are reasonable and make sense.
Compute the energy content (supply) of the sun for each of these assumptions. How long could the sun shine at its current luminosity from each of these energy sources?

[4 marks]