

AST 250 – Spring 2019
Homework Due: Monday April 1

29. Measurements of Jupiter indicate that it radiates in the infrared with a total flux of 14.1 W/m^2 . In this problem, you will explore the origin of this emission. Some physical variables you will need: $R_{\text{Jup}} = 6.99 \times 10^7 \text{ m}$, $a = 5.2 \text{ AU}$, $M_{\text{Jup}} = 1.9 \times 10^{27} \text{ kg} \sim 318 M_{\text{Earth}}$.
- (a) What is the total rate of energy emitted by Jupiter in the infrared? Give your answer in Watts.
 - (b) What is the rate of energy absorbed by Jupiter from solar radiation? Assume Jupiter has an albedo of $A = 0.343$. Give your answer in Watts.
 - (c) Calculate the excess $(dE/dt)_{\text{internal}}$ emitted by Jupiter?
 - (d) One possibility is that radioactive decay of elements may account for this excess energy. Using the Earth as an analogue, radioactive decay of long-lived radioactive isotopes (such as ^{40}K , ^{238}U etc.) account for $\sim 2 \times 10^{13} \text{ W}$ in the Earth. Assuming Jupiter has the same mass fraction of radioactive elements as the Earth, what would be the radioactive heating rate for Jupiter?
 - (e) Since the radioactive heating rate is far too small to account for the difference, what about gravitational contraction (dU/dt) ? Assume Jupiter is a **uniform density sphere** contracting at a rate dR/dt . What contraction rate (dR/dt) give as km/Gyrs) could account for the excess energy? Hint: Differentiate U and set $dU/dt = \text{excess energy emitted}$.
 - (f) Assuming dR/dt has been the same over 4.6 Gyrs, What fraction of Jupiter's present radius has it contracted?

