Physics of Stars

practice exam
Wednesday 8 June 2016, 13:00–15:00

Write clearly and be explicit in your answers, writing each step of your calculations.

1) The optical spectrum of a faint star indicates a spectral type of G2V and a geometric parallax measurement places it at a distance of 100 parsec. However, the star is observed to be 10 magnitudes fainter than expected. A sub-millimetre observation indicates the presence of an intervening, dark, spherical cloud of gas with a diameter of 100 AU, a temperature of 30 K and an opacity in the optical part of the spectrum of k=0.002 cm^2 g^{-1} with no optical emissivity.

a) Assume a uniform density and calculate the density ρ of this cloud.

b) Assume a hydrogen mass fraction of X=0.75, a helium mass fraction of Y=0.25 and a negligible metallicity. Is this small cloud stable against collapse?

c) How much energy could be released to the surrounding interstellar medium if this cloud would fully collapse?

d) If 10% of the mass of this cloud would collapse onto a single central object, would a star be formed? If not, why not? If yes, what would be roughly the spectral type of the star once it has arrived on the Main-Sequence?

2) This question concerns atomic absorption lines in an optical spectrum.

a) Describe in words the formation process of an optically thin atomic line in the atmosphere of a star. Use the following key words: continuum, flux, opacity, core of the line, wings of the line, optical depth, geometric depth, temperature.

b) A weak line has a Gaussian shape with a Full Width Half Maximum of 2 Å and a maximum depth of 1/π of the continuum flux. Calculate the equivalent width of this line.

Note the standard integral $\int_0^\infty e^{-a x^2} = \frac{1}{2}\sqrt{(\pi/a)}$

c) An absorption line is observed to be saturated. Make a clear sketch of the shape of this line in relation to the continuum flux in the spectrum. For clarity, describe the shape of this line in words.

3) This question deals with the energy production process in stars.

a) Explain why the proton-proton chains dominate the nuclear energy production in low-mass stars on the main sequence.

b) In the CNO-I cycle, the following nuclear reactions occur:

$^{15}O \rightarrow {}^{15}N + \ldots$

$^{1}H + {}^{15}N \rightarrow {}^{12}C + \ldots$

Use the various conservation laws to argue which missing particles are created in these reactions.

c) Calculate how much total energy each of these reactions deliver to the stellar plasma.