Universität Bonn Summer Term 2009

Physics of the ISM

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Exercises IX

In-class problems

1 Ionized gas

Pulsar observations yield a rotation measure along the line of sight of $RM = -60$ rad m^{-2} and a dispersion measure of $DM = 20$ pc cm^{-3}. The *dispersion measure* is given by

$$DM = \int_0^{s_0} \left(\frac{n_e}{\mathrm{cm}^{-3}}\right) \left(\frac{ds}{\mathrm{pc}}\right) \ \mathrm{pc\ cm}^{-3} \ ,$$

and the *rotation measure* is given by

$$RM = 0.81 \cdot \int_0^{s_0} \left(\frac{n_e}{\mathrm{cm}^{-3}}\right) \left(\frac{B_{||}}{\mu\mathrm{G}}\right) \left(\frac{ds}{\mathrm{pc}}\right) \ \mathrm{rad\ m}^{-2} \ ,$$

Calculate the mean strength of the component of the magnetic field along that line of sight.

2 Hot gas

The cooling time of a hot plasma due to thermal bremsstrahlung is

$$\tau_{\mathrm{cool}} = 8.5 \cdot 10^{10} \cdot \left(\frac{n_e}{10^{-3}\mathrm{cm}^{-3}}\right)^{-1} \cdot \left(\frac{T_e}{10^8\mathrm{K}}\right)^{-1/2} \ \mathrm{yr} \ .$$

Calculate the cooling time of the hot coronal gas in the Milky Way, which has an average density of $n_e = 0.05$ cm^{-3} and a mean temperature of $T = 10^6$ K. How does this compare to the synchrotron cooling time of relativistic electrons with energy $E = 3$ GeV in a mean magnetic field of strength $B = 5$ μG? This cooling time is equivalent to the half-life time of the particles

$$t_{1/2} = 8.24 \times 10^9 \ \left(\frac{B}{\mu\mathrm{G}}\right)^{-2} \left(\frac{E}{\mathrm{GeV}}\right)^{-1} \ \mathrm{yr} \ . \tag{1}$$

Homework

3 Ionized gas

Write down the integrals of the emission measure, rotation measure and dispersion measure.

(a) By which means can these quantities be measured?

(b) What kind of information do they contain?

4 Chemistry

(a) What kind of chemical reactions occur in the ISM?

(b) What is the importance of ions?

(c) What is the role of dust?

5 Photo-dissociation regions

(a) What are the main coolants of PDRs?

(b) Sketch the structure of a spherical PDR.

6 Hot gas

What is the dominant cooling process in a 10^8 K gas?