Radboud Universiteit Nijmegen
Afdeling Sterrenkunde
Jörg R. Hörandel

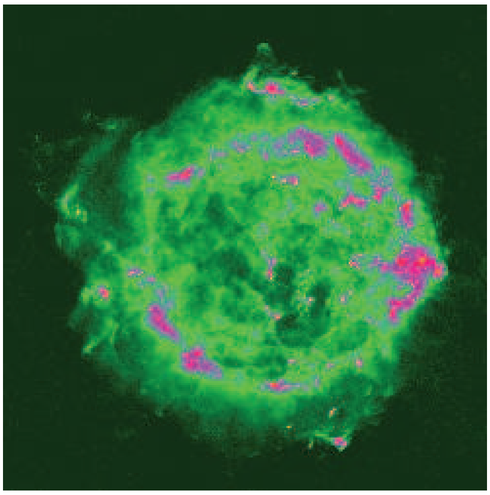
Radioastronomie – 2008/09

Werkcollege 4 – 12.03.2009

1. **Non-thermal radiation**
   The source Cassiopeia A is a cloud of ionized gas associated with the remnant of a star which exploded about 330 years ago. The radio emission has the relation of flux density as a function of frequency as shown during the lecture and tabulated below. For the sake of simplicity, assume that the source has a constant temperature and density, in the shape of a ring, with thickness 1' and outer radius of angular size 5.5'. What is the actual brightness temperature at 100 MHz, 1 GHz, 10 GHz, and 100 GHz?

   Hint: $S = 2kT_B\Omega/\lambda^2$.

wavelength λ [m]	Flux density S [Jy]
3	$1.9 \cdot 10^4$
0.3	$3.4 \cdot 10^3$
0.03	750
0.003	~ 130



Cassiopaia A as seen by the VLA in the radio frequency range.

2. **Synchrotron radiation**
   Obtain the integrated power and spectral index n for synchrotron radiation from an ensemble of electrons which have a distribution

$$N(E) = N_0.$$

   That is a constant energy distribution from E_{min} to E_{max}. Give the frequency dependence of the emissivity $\epsilon \propto \nu^n$.

   Hint: The power emitted by a single electron is $P_e = CE^2B^2$, where C is a constant, E the energy of the electrons, and B the magnetic field strength.

see reverse side!

3. **Dust emission and optical depth**
The Orion hot core is a molecular source with an average temperature of 160 K, angular size 10", located 500 pc from the Sun. The average local density of H_2 is 10^7 cm^{-3}.

(a) Calculate the line-of-sight depth of this region in pc, if this is taken to be the diameter.

(b) Calculate the column density, $N(H_2)$, which is the integral of the density along the line of sight. Assume that the region is uniform.

(c) Obtain the flux density at a wavelength of 1.3 mm using $T_{dust} = 160$ K, the parameter $b = 1.93$, and solar metalicity ($Z = Z_\odot$) in the equation for the column density

$$N(H) = 1.93 \cdot 10^{15} \frac{S_\nu}{\theta^2} \frac{\lambda^4}{(Z/Z_\odot) b T_{dust}}.$$

λ is the wavelength in μm, the source size θ is in arc seconds, and N_H is in cm^{-2}.

Optical image of the Orion hot core.