The Universe at Radio Wavelengths PHYS 6211.01

Assignment 2 *Due: Tuesday, 24 November 2020, 10:30 am*

1. Determine geometrically the distance, D, to the Whirlpool galaxy M51 by using the Expanding Shock Front Method. This method combines Doppler measurements of expansion velocities from optical hydrogen line observations with independent radius measurements from radio observations. You will determine the distance to the supernova and therefore to the galaxy with sets of radius determinations from three epochs.

   The radii from the optical observations are simply determined through: $r_i = 1.1 \cdot v \cdot (t_i - t_0)$ where v is the velocity from optical hydrogen lines, $t_i - t_0$ is the time of the measurement since the time of explosion, The factor 1.1 is a correction factor needed to relate the optical radii with the radio radii. The velocity v is measured to be 23,000 km/s.

   The radius values from radio observations have to be derived from synchrotron selfabsorption (SSA) spectra for the supernova. The flux density measurements for different frequencies and several epochs are given in Krauss et al. (2012) in Table 1 and 2. For the assignment we take the data for June 26, July 6 and July 16 at all 13 frequencies from 1.4 to 36 GHz. The time since explosion, $t_i - t_0$ is given under "Day."

   a. Search the web and find a picture of M51 and display it in your document. Use the finding chart below and indicate with an arrow where the supernova is approximately located on your picture.

   b. List the flux density measurements with errors for each of the three epochs in Table 1.

   c. For each epoch, fit the function under equation 1 in Krauss et al. (2012). In the equation, use p=2.8. Use a weighted fit and solve for the parameters, $S_{\nu\tau}$, and ν_τ. Plot the data points and the fit function. Label the axes appropriately. Your plots should be comparable to those in Figure 1 of Krauss et al. (2012).

   d. Determine with your program for each of the three curves, the maximum flux density, $S_{max, i}$ and the frequency at which the maximum occurs, $\nu_{max, i}$. List the two fit values and the two values for the maximum of the curve for each of the three epochs in Table 2.

e. Compute the radius , r_i in cm of the supernova with $r_i = 1.1 \cdot \upsilon \cdot (t_i - t_0)$ for the three epochs using the velocity, υ =23,000 km/s . List r_i also in Table 2.

f. Use equation 2 in Krauss et al. (2012) with $\alpha = 1$ and f = 0.5 and determine for each epoch, D_i in Mpc for which the linear radius, $R_{s, i}$, equals r_i. List $R_{s, i}$ and D_i also in Table 2.

g. Compute the mean, D, of D_i and compare it with a range of values in the literature between 6 and 10 Mpc with a mean of 7.8 Mpc.

Finding chart of SN 2011dh in M51

https://skyandtelescope.org/online-gallery/m51-and-sn2011dh/

Figure 1