The Interstellar Medium --- HW20210531

due June 11 (Friday)

1. Dispersion of ionized interstellar medium ($n_e \approx 0.1\ \mathrm{cm}^{-3}$) causes the arrival time of a pulse to be later at lower observed frequencies. A pulse (width of 10 ms) of the radio pulsar CP 0328 has arrival times measured at 151, 408, and 610 MHz as shown below. Estimate its distance and show that the size of the emission region cannot be larger than about 3,000 km.

Frequency of observation MHz	**Time lapse Δt s**
151	
	4.18
408	
	0.367
610	

2. DR 21 is a compact H II region that is not optically visible but is very bright in the radio and infrared wavelengths. Its spectral energy distribution is shown below (taken from Righini et al. 1976, ApJ, **207**, 119), in which the emission shortward of ~8 mm is due to thermal emission of heated dust and does not concern us at this moment. Assume that the source is at a distance of 3 kpc and is a spherical pure hydrogen nebula with an angular diameter of 15". Estimate the emission measure and electron density in DR 21. Calculate the ionizing flux exciting the nebula, and hence estimate the spectral type of the star exciting the nebula, assuming the star to be the only ionizing source.

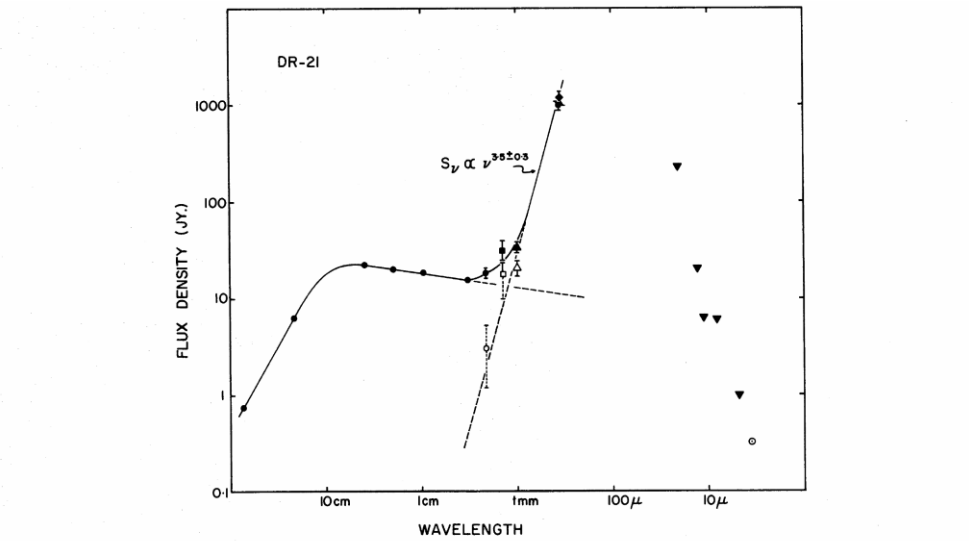

FIG. 2*b*.—Spectrum of DR-21. The sources of the data are: 21 cm and 73 cm, Ryle and Downes (1971); 9.5 mm to 3.85 cm, Ulich *et al.* (1973) and Dent (1972); 3.2 mm, this work; 2.1 mm, Ulich (1974); 1.4 mm, Ade *et al.* (1974); 1.0 mm, Werner *et al.* (1975); 350 μ, ◆—this work, ●—Rieke *et al.* (1973); ▼—Wynn-Williams *et al.* (1974); ○—Righini (in preparation). The closed symbols at 2.1 mm, 1.4 mm, and 1.0 mm are the observed values, and the open symbols are our estimates of the emission of the submillimeter source after correction for the free-free emission of DR-21 (see text).