THE TEMPERATURE AND INTERNAL KINEMATICS OF M8

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Abstract. A photoelectric Fabry-Pérot spectrometer is used to record the line profiles of Hα and [NII] at 22 points in the nebula. The ratio of intensity Hα/[NII] is used to derive an electron temperature distribution with values between 5700° and 9100° showing a peak at the centre of density. These temperatures are compared with the Hα Doppler temperatures to estimate excess velocities of mass motion. Together with the shifts of the Hα line centres, these lead to an evaluation of the velocity field in the nebula.

It is suggested that the nebula consists of a core expanding at about ± 10 km/sec⁻¹ surrounded by a thick peripheral shell in which large scale mass motions are small. Non-thermal broadening suggesting turbulent velocities at about the speed of sound is observed in this shell and is attributed to small scale dynamic effects in a non-smooth density distribution. The effect of such expanding cores on heliocentric velocities of galactic H II regions is discussed.

1. Introduction

The diffuse nebula M8 (NGC 6523) is associated with the open cluster NGC 6530 and has coordinates α = 17h 59m, δ = -24° 24'. Together with three other bright H II regions (M16, M17, M20) whose internal kinematics will be studied in future papers, M8 is associated with the Sagittarius spiral arm which is thought to pass at about 2 kpc from the sun between it and the galactic nucleus. Walker (1957) has obtained a distance of between 1.4 and 2.0 kpc for NGC 6530 on the basis of a distance modulus derived from the cluster’s H-R diagram.

The nebula itself shows a roughly spherical core of about 8 pc diameter (assuming r = 1.5 kpc) cut by tongues of heavily obscuring dust. The total extent of the H II region is shown on long exposure plates (such as that in the Palomar Sky Atlas) to be at least twice that of the bright core mentioned above. The symmetry of the nebula is important if an attempt is to be made to construct a dynamical model. Mezger and Henderson (1967) have studied the thermal continuum of M8 at 6 cm. Their isophotes give a picture of the ionized region uninfluenced by the superimposed dust absorption lanes. The appearance of these contours suggests that the nebula can reasonably be regarded as spherically symmetric to at least 5 pc radius from the point of maximum brightness.

It has been pointed out by Walker (1957) that the ionized region is surrounded by a zone of low star density. This would suggest that the region is radiation limited and that the ionized region is only part of a larger complex of H I and dust. It is plausible that the Trifid Nebula, NGC 6514, is another ionization centre within the same complex.

A 21-cm absorption profile has been obtained from M8 by Clark (1965), giving some idea of the movement of this associated H I. Unfortunately the nebula was not...
included in the comprehensive 21-cm emission line survey of neutral hydrogen shells associated with H II regions carried out by Riegel (1967).

The primary source of excitation is identified as the O5 star HD 164794 (9 Sgr) by both Pottasch (1965) and Miller (1968) who base their choice on the list of OB stars by Morgan et al. (1955). However, there is some question whether 9 Sgr is a member of NGC 6530 (Walker, 1957). Moreover, the point of highest density in the nebula is well away from HD 164794 and is associated with a region of obscuring material (Thackeray, 1950). An anomalous extinction of less than 5 magnitudes would be sufficient to exclude an O star of absolute magnitude -6 in this region from the survey by Morgan et al. Although the cluster was extensively studied by Walker (1957) his survey of the members purposely avoided regions of high nebular brightness and dust obscuration. It seems then that although 9 Sgr is capable of ionizing the central core if it is located near to it in space, the presence of a second O star hidden nearer the centre of density cannot be discounted for the moment.

Mezger and Höglund (1967) have derived a temperature of about 6000 K for the central part of the nebula on the basis of measurements of the 109α recombination line and of the thermal continuum. Dieter (1967) uses the same method on the 158α recombination line to derive a temperature of about 4500 K. However, it is not clear that radio recombination lines provide useful estimates of $T_e$ (Kaler and Lee, 1967).

Pronik (1960) used the Hβ/[OII] and Hβ/[OIII] ratios to derive a temperature distribution across the nebula. His results indicate values of 8500 K near the centre of the bright core decreasing to 7500 K near the I-front. Burbidge et al. (1963) have studied the question of ionic abundances and electron temperatures with specific reference to the Hα/[NII] intensity ratio. They use a value of $f=n(N_{II})/n(N) = \frac{1}{2}$ for H II regions in the spiral arms of the Galaxy and compute a $T_e$ of 5800 K for M8. This low value has been questioned by Osterbrock (1965). In general it seems that there exists sufficient uncertainty in element and ion abundances, stellar colour temperatures and nebular density distributions so that even estimates of $T_e$ calculated from accurate collision strengths can only be regarded as upper and lower limits.

The internal motions in M8 have been previously studied optically by Courtès (1960) and Shcheglov (1963). The former used a photographic Fabry-Pérot to derive a velocity of $-7$ km/sec$^{-1}$ for the nebula as a whole with respect to the sun. Examination of his spectrogram indicates that it represents internal motions consistent with the hypothesis that the brightest portion of the nebula is moving towards the observer at about 10 km/sec$^{-1}$ with respect to the gas in the outlying regions. It is significant to the analysis of the present results that Courtès also found anomalously low Hα/[NII] ratios approaching unity in M8. Shcheglov has used an image converter to photograph the Fabry-Pérot fringes produced by M8. He deduces the high expansion velocity of $\pm 25$ km/sec$^{-1}$ (Gerschberg and Shcheglov, 1963).

In addition to these direct measurements of expansion velocities in M8, Mezger and Höglund (1967) have found that it was necessary to postulate turbulent velocities of $12$ km/sec$^{-1}$ in order to explain the Doppler width of the 109α line in excess of that expected from $T_e \approx 6000$ K. This result was supported by the observations of Dieter