which has a very large negative shift, and may be related to the star itself, all other He I absorption components fall within the radial velocity range covered by the emission lines, and therefore could arise in the same region where the emission lines are being formed. The strongest evidence in favor of this idea is that two stars detached from the main body of the Huyghenian region, namely HD 37061 and HD 36982, showing the He I absorption line, have condensations of nebular material around them, while other stars at about the same distance from the Trapezium do not show it. Further work on the He I nebular absorption, mainly through observation of the λ 10830 line profile, will no doubt clarify the role which density and ionization fluctuations (Lyman-alpha energy density?) play in the dynamics of the nebular material.

REFERENCE

1. Wilson, O. C., Münch, G., Flather, E., Coffeen, M. F. *Astrophys. J. Suppl.*, **4**, 199, 1959.

DISCUSSION

S. von Hoerner. If we want to understand the velocity distribution of the gas in the Orion Nebula, we face the following severe problem. The Mach numbers in the Nebula are near and above unity, but we neither have a theory of supersonic turbulence nor do we have laboratory experiments of this type; there is actually nothing reliable to which the observations might be compared. If we try the theory of incompressible turbulence ($M \ll 1$), we may get a fair fit for the velocity distribution (i.e., the Kolmogoroff spectrum) but we encounter the difficulties just mentioned by Dr Münch. On the other hand, I have tried the other extreme, neglecting completely the usual concepts of turbulence and using a model of the Nebula which consists of plane-parallel random shock waves having no mutual correlation. This model gives a somewhat better fit for the velocity distribution, and avoids the difficulties connected with the line width (but should, of course, not be regarded as giving a true picture of the Nebula). The truth will be, as is always the case, somewhere between these two extremes.

8. THE STRUCTURE OF THE He I λ 10830 EMISSION LINE IN THE ORION NEBULA

A. H. Vaughan, Jr.

The structure and intensity of the infra-red helium triplet at 10830 Å in the Orion Nebula was recently investigated photoelectrically by means of a pressure-scanning Fabry-Pérot interferometer attached to the Kitt Peak 16- and 36-inch telescopes, at a spectral resolving power of 40 000 and spatial resolution of about 0·7 minute of arc. Eight regions within 4′ of θ^1 Ori were studied.

The $2^3P^\circ_{1,2} \rightarrow 2^3S_1$ fine structure components are blended because of thermal velocities and unresolved turbulence in the Nebula. This blend has an apparent heliocentric radial velocity systematically about 15 km/sec greater than the velocities of [O III] λ 5007 and He I λ 4471. The resolved $2^3P^\circ_0 - 2^3S_1$ fine structure component has an intensity relative to the blend of only about $\frac{1}{16}$, instead of $\frac{1}{8}$ (the ratio of statistical weights). The separation between the two observed components is about 1·5 Å, instead of 1·20 Å (the RMT value).

The r.m.s. velocity of unresolved turbulence in one dimension derived from the observed line widths is about 5·5 km/sec. This is significantly smaller than was found by Wilson, Münch *et al.* for [O III], [O II], and Hγ.

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The surface brightness distribution along an east-west path through the Trapezium was measured at three wavelengths within the blended emission component. The observed brightness distribution agrees to within 20 per cent with the distribution of emission measure calculated from a spherically-symmetrical electron-density model derived from [O II] $\lambda 3729/\lambda 3726$ intensity ratios by Osterbrock and Flather, and with the brightness distribution including reddening corrections derived from Hβ flux measurements by Mendez. This agreement suggests that the core may be assumed optically thin in first approximation.

It is suggested that the observed contours and intensities of the $\lambda 10830$ line can be quantitatively interpreted by assuming that self-absorption by He I (2^3S) is taking place in an expanding shell surrounding the Nebula. In particular, the required velocity distribution of He I (2^3S) is found to be consistent with the envelope of interstellar He I $\lambda 3889$ absorption observed in the spectra of the Trapezium stars. It is estimated that about 70 per cent of the $\lambda 10830$ photons originally emitted by the bright, but optically thin, core of the Nebula, are deleted from the line of sight by scattering in the expanding zone. The apparent optical depths at $\lambda 10830$ are consistent with those at $\lambda 3889$ provided secondary scattering in the expanding zone is taken into account.

9. THE TIME SCALE OF THE NEBULA

P. O. Vandervoort

In a discussion of the 'time scale' of the Orion Nebula one is primarily interested in the age of the Nebula or, more precisely, in the interval of time that has elapsed since the radiation in the Lyman continuum of the exciting stars θ^1 Ori C and θ^2 Ori A first ionized and heated the gas. Presumably, this time scale also refers to the ages of the exciting stars and of the stars in addition to θ^1 Ori C which are members of the Trapezium. The age is derived from the comparison of a gas-dynamical model of the Nebula with observational results concerning the distributions of the density and the velocity of expansion of the ionized gas.

The interpretation of the relevant observational data must be based on a knowledge of the geometry of the Nebula. According to Osterbrock and Flather (1), Menon (2), Wilson, Münch, Flather, and Coffeen (3), and others, it appears that the Nebula is approximately spherically symmetric about the Trapezium. Menon (2) has derived a spherically symmetric model of the distribution of the electron density from the distribution of the surface brightness at a wavelength 3·75 cm. In their investigation of the Doppler shifts and widths of the spectral lines Hγ, $\lambda 3726$ [O II], and $\lambda 5007$ [O III], Wilson *et al.* found evidence that the Nebula is expanding with a velocity of approximately 10 km/sec in an inner region where the lines of [O III] originate and a velocity of approximately 7 km/sec in an outer region where the lines of [O II] originate. The precise locations of these regions are not known; however, since the lines of [O III] are very faint at distances from the Trapezium greater than 5′ (1), it can be argued that the observed radiation in these lines originates within the corresponding linear distance from the Trapezium.

The construction of a gas-dynamical model of the Nebula is made difficult by the characteristic feature of the evolution of an H II region that the state of motion of the ionized gas is determined by the initial state of the cloud of neutral gas in which the H II region forms and by the manner in which the exciting stars begin to radiate in the Lyman continuum (4). After the onset of the ionizing radiation, an H II region grows as the ionization front separating the

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