of sight would generally give quite normal smooth profiles for such a model without any separation of peaks. Further, the region to the north of the object where only a single narrow peak appears would require a fairly sudden change-over from these expanding regions to a smooth non-expanding distribution of gas.

*Thackeray:* Is it quite impossible to explain the double peaks in terms of central absorption in the profile?

*Hindman:* Two possible types of absorption may be considered: (1) Absorption due to a continuum source which is not observed at 1410 Mc/s. (2) Self-absorption due to temperature variation in the gas. This seems unlikely for two reasons: Firstly, the minimum between the peaks falls to a very low value, less than 10 °K $T_A$, and this is a very low temperature for gas in clouds having a velocity dispersion of 25 to 30 km/sec. Secondly, the half of the area to the north of the system shows only a single narrow feature; it seems unlikely that low-temperature gas should cease to exist or that the velocity range should suddenly contract to less than half that applicable to the rest of the region.

I feel that these explanations require much more imagination than to accept the separated masses of gas.

*Oort:* You discussed the possibility that the phenomenon of the two peaks might be due to an expansion. In view of the total mass of the Cloud it seems that an expansion with a velocity of 20 km/sec could hardly persist for a long time. The matter would be drawn back again.

*Hindman:* My remarks on this point were in answer to Dr. Kerr's question and I agree entirely with Professor Oort that there is good reason to be suspicious of the reasoning involved.

*Gascoigne:* To clarify, I take it that your results imply that the neutral H in the SMC appears divided between about six large parts, the masses of each of which can in principle at least be determined from the profiles.

*Hindman:* Yes, there are three main regions. The mass determination is not always straightforward because of the necessity to separate the gas associated with overlapping peaks; higher-frequency resolution may assist in this.

# 56. OPTICAL EVIDENCE ON THE KINEMATICS OF THE MAGELLANIC CLOUDS

M. W. Feast
Radcliffe Observatory

Some while ago radial velocities were published for 112 stars in both Magellanic Clouds from Radcliffe Cassegrain spectrograms (Feast, Thackeray, and Wesselink 1960).

An analysis of the stellar velocities (Feast, Thackeray, and Wesselink 1961) provided interesting information on the rotation and velocity dispersion in the Clouds but more data were needed to settle various doubtful points. Shortly after the installation of the Radcliffe coudé spectrograph it was found possible to obtain spectra of the brighter emission nebulae in the Clouds at 15 Å/mm. The sharpness of the emission lines and the relatively high dispersion yields velocities of high weight. During the years 1960–63, 48 coudé spectra of 42 regions of nebulosity in the Large Cloud were obtained. The details of the radial velocities derived from these plates are being prepared for publication elsewhere. To these velocities could be added the mean velocity of the great 30 Doradus nebula determined in an earlier investigation (Feast 1961) from Cassegrain observations at many different points

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in the nebula. These 43 emission nebulae are well distributed over the Large Cloud. A least-squares solution for solid body motion yields results in agreement with those previously found for the stars though with somewhat greater accuracy. In particular the direction of maximum velocity gradient is found to be near position angle 171° as it was for the stars, in agreement with the major axis of de Vaucouleurs' faint outer isophotes.

The results from the nebulae and the stars have been combined to investigate differential rotation in the LMC. The optical evidence for differential rotation within 3°.5 of the centre of the Clouds seems now to be quite well established. The rotation curve is symmetrical about the radio centre of the LMC, *not* the optical centre. This result undoubtedly complicates the proper interpretation of the dynamics of the LMC. The mean rotation curve derived from the peaks of the 21-cm profiles agrees fairly well with the optical rotation curve.

Combining the results for stars and nebulae in an analysis assuming circular motion in de Vaucouleurs' inclined plane model of the LMC leads to estimates of the mass of the Cloud in the range $0 \cdot 5$ to $1 \cdot 0 \times 10^{10}$ solar masses.

The velocity dispersion for the 43 nebulae in the LMC is $9 \cdot 3 \pm 1 \cdot 3$ (s.e.) km/sec. Sixty-one supergiant stars yield the higher dispersion of $15 \cdot 2 \pm 2 \cdot 1$ (s.e.) km/sec. Furthermore, the earlier Radcliffe work (Feast, Thackeray, and Wesselink 1961) indicated an apparent difference in dispersion in the inner and outer parts of the LMC as well as a possible dependence on magnitude. There is, however, no difference in the velocity dispersion of the nebulae in the inner and outer parts. A further study of the stellar results reveals that the dispersions obtained from them are strongly affected by five stars with large radial velocity residuals ($>35$ km/sec). If these five large residuals are omitted there is no significant difference in the dispersions in the inner and outer parts of the LMC and the mean dispersion for the stars is $10 \cdot 5 \pm 2 \cdot 1$ (s.e.) km/sec, in excellent agreement with the results for the nebulae.

It is of interest that in the SMC, also, of 41 stars with measured radial velocities, 5 have unusually large residuals ($>35$ km/sec) from a solid body rotation solution. So far as can be seen from the relatively small number of stars available, the omission of the large residuals makes the distribution of residuals much more nearly gaussian in both Clouds.

If, as seems rather likely, very massive stars evolve at nearly constant bolometric magnitude, the stars so far observed for radial velocity in the Clouds will have evolved from very high up on the main sequence, from amongst the O and early B type stars. It seems reasonable therefore to suppose that the stars with large radial velocity residuals in both Clouds are related to the high velocity O and B type stars (the run-away stars) found in the Galaxy.

That these run-away stars are found amongst young massive stars in both Magellanic Clouds, as well as in the Galaxy (and also in roughly the same proportions), strongly suggests that this phenomenon is of a rather fundamental nature. The hypothesis of Zwicky and Blaauw that these stars originate in binary systems, one member of which undergoes rapid mass loss, would appear to fit the observations both in the Galaxy and the Magellanic Clouds.

The velocity dispersion amongst the nebulae in the LMC is not significantly different from the velocity dispersion within the 30 Doradus nebula, $11\cdot3 \pm 3\cdot2$ (s.e.) km/sec (Feast 1961).

The low-velocity dispersion found for young objects in the LMC implies that if the axis of rotation makes only a small angle with the line of sight, as is the case in de Vaucouleurs' model, then the system of nebulae and supergiants must be highly flattened to the plane.

Further work on emission nebulae in the Clouds is in progress. Some low dispersion spectra of faint nebulae far out along the major axis of the LMC have been obtained and it is also intended to use the coudé plates to derive relative intensities of the [OII] ultraviolet lines and to deduce electron densities from these measurements.

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*Discussion*

*Woolley:* Have you considered the effect on the curve of rotation of a change in $\Theta_c$?

*Feast:* I have used the same figure 270 km/sec as in our previous paper in order to obtain a quick comparison. When we wrote the previous paper, we considered the question and decided that any reasonable variation of the value should not affect the rotation curve.

*Aller:* Which nebular spectral lines did you use?

*Feast:* Mostly the [OII] lines. These are the strongest lines in the photographic region. We sometimes measured the Balmer lines or [NeIII] for the brighter nebulae.

*Aller:* Did you find any evidence for internal motions (doubling or deformation of lines) or different velocities for the green nebular lines of [OIII] and [OII] $\lambda$3726, 3729?

*Feast:* I did not measure the green nebular lines on the coudé. I do not think we can say anything about differential motion from the present measurements. There is, of course, a conspicuous variation in electron density.

*Kerr:* I would like to summarize the present position regarding radio evidence on the kinematics of the Clouds. The rotation curve for the Large Cloud derived from the 1960 observations agrees fairly well with the 1953 results, but the analysis of the later observations was not pushed very far, because high-resolution studies were just beginning. Optical and radio rotation velocities can now be compared more systematically by isolating smaller areas.

*Buscombe:* There is tantalizing though slender evidence that the SMC globular clusters share a distribution of higher velocities than the supergiants, relative to the Sun.

## 57. COMPARISON OF STELLAR ORBITS IN THE LARGE MAGELLANIC CLOUD AND IN THE GALAXY

L. Perek

Astronomical Institute of the Czechoslovak Academy of Sciences

The rotation curves of the LMC and the Galaxy differ markedly by the slope of the curve near the centre. Two causes may be responsible for this difference. Firstly, the mass of the Galaxy exceeds that of LMC by about one order of magnitude

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