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THE RADIAL VELOCITY OF THE ANDROMEDA NEBULA

Keeler, by his splendid researches on the nebulæ, showed, among other things, that the nebulæ are generally spiral in form, and that such nebulæ exist in far vaster numbers than had been supposed. These facts seem to suggest that the spiral nebula is one of the important products of the forces of nature. The spectra of these objects, it was recognized, should convey valuable information, and they have been studied, photographically, first by Huggins and Scheiner, and recently more extensively by Fath and Wolf; but no attempt has to my knowledge been made to determine their radial velocity, although the value of such observations has doubtless occurred to many investigators.

The one obstacle in the way of the success of this undertaking is the faintness of these nebulæ. The extreme feebleness of their dispersed light is difficult to realize by one not experienced in such observing, and it no doubt appears strange that the magnificent Andromeda Spiral, which under a transparent sky is so evident to the naked eye, should be so faint spectrographically. The contest is with the low intrinsic brightness of the nebular surface. a condition which no choice of telescope can relieve, However, the proper choice of parts in the spectrograph will make the best of this difficulty. The collimator must of course fit the telescope, but the dispersion-piece and the camera may and should be carefully selected for their special fitness for the work. While the speed of the camera is all-important in recording the spectrum, the detail in the spectrum depends upon the dispersion, for obviously a line, no matter how dark it may be, must have a certain magnitude or else it cannot be recorded by the granular surface of the photographic plate. Hence the light must be concentrated by a camera of very short focus and the dimension of the spectral line be increased by using a high angular dispersion and a wider slit, as one in this way attains a higher resolving power in the photographed spectrum.

Although I had made spectrograms of the Andromeda Nebula a few years ago, using the short camera, it was not until last summer that I thought to employ the higher dispersion and the wider slit. The early attempts recorded well the continuous spectrum crossed by a few Fraunhofer groups, and were particularly encouraging as regards the exposure time required. The first of the recent plates was exposed for 6 hours and 50 minutes, on September 17, 1912, using a very dense 64-degree prism, the instrument having already been tried out on some globular star clusters. When making this exposure the brightness of the nebula on the slit-plate compared with that of the clusters indicated that one night's exposure should suffice for the single-prism, and suggested that, by extending the exposure through several nights, one could employ the battery of three dense flint prisms whose dispersion would make it possible to observe the velocity of the nebula. The success of the plate bore out this suggestion. Indeed, upon subsequent examination of this plate it was seen that the nebular lines were perceptibly displaced with reference to the comparison lines. The next plate secured showed the same displacement. Still other single-prism plates were obtained during the autumn and early winter, but the observing program with the 24-inch telescope did not allow an opportunity to carry out the original plan to make the longer exposure spectrogram with the prism-train.

These spectrograms were measured with the Hartmann spectrocomparator, using a magnification of fifteen diameters. A similar plate of Saturn was employed as a standard. The observations were as follows:

1912,	September 17,	Velocity,	—284 km.
	November 15–16,	"	296
	December 3–4,	"	308
	December 29–30–31,	"	—301
		Mean velocity,	—300 km.

Tests for determining the degree of accuracy of such observations have not been completed, but in rounding off to 300 kilometers in taking the mean one is doubtless well within the accuracy of the observations. The measures extended over the region of spectrum from F to H.

The conditions were purposely varied in making the observations. This was done although it was early noted that the shift at the violet end of the spectrum was fully twice that at the blue end, which should be the case if it were due to velocity.

The magnitude of this velocity, which is the greatest hitherto observed, raises the question whether the velocity-like displacement might not be due to some other cause, but I believe we have at the present no other interpretation for it. Hence we may conclude that the Andromeda Nebula is approaching the solar system with a velocity of about 300 kilometers per second.

This result suggests that the nebula, in its swift flight through space, might have encountered a dark "star," thus giving rise to the peculiar nova that appeared near the nucleus of the nebula in 1885.

That the velocity of the first spiral observed should be so high intimates that the spirals as a class have higher velocities than do the stars and that it might not be fruitless to observe some of the more promising spirals for proper motion. Thus extension of the work to other objects promises results of fundamental importance, but the faintness of the spectra makes the work heavy and the accumulation of results slow.

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