A New Method to Derive the Distances of Spiral Galaxies

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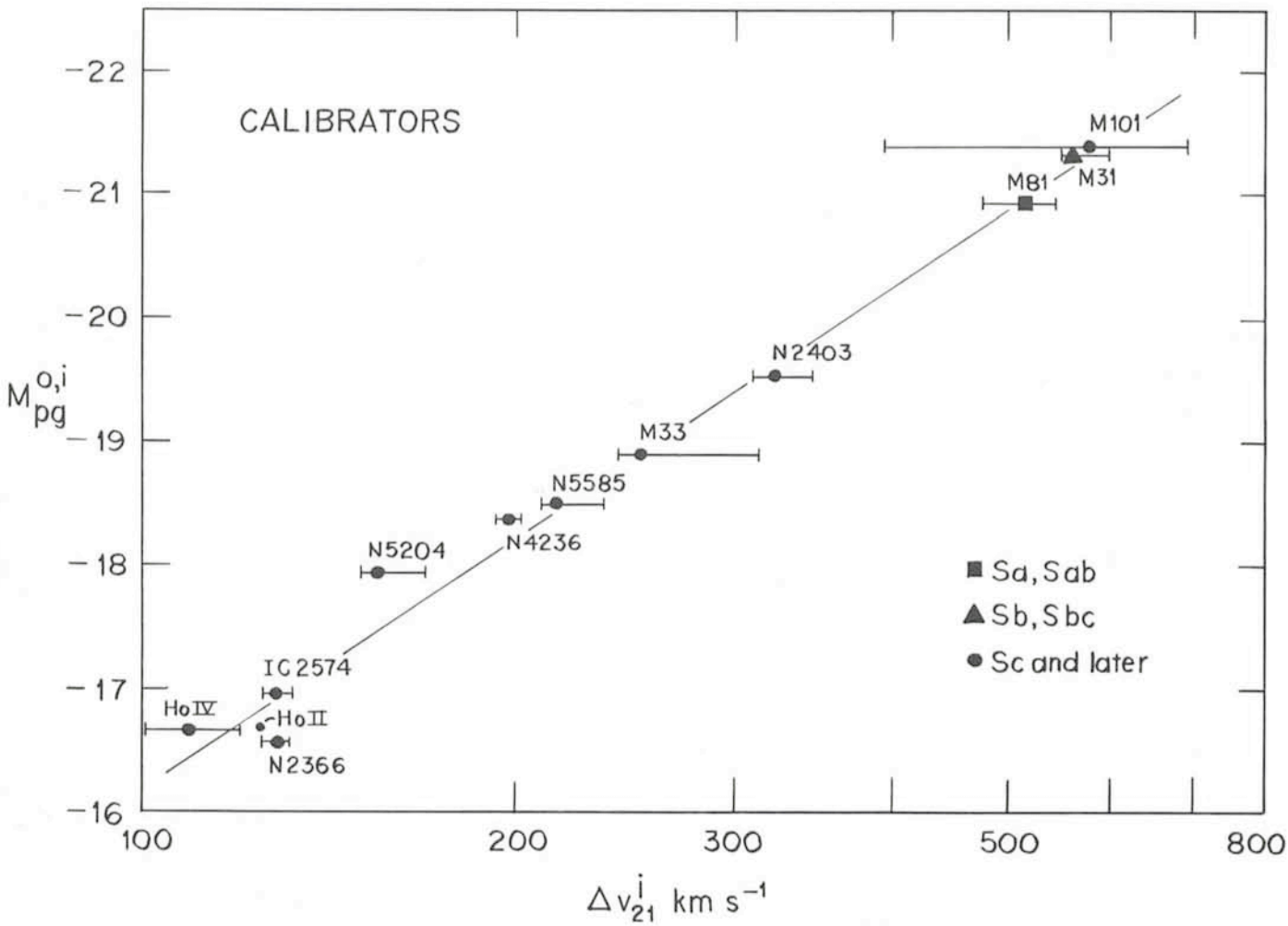
A new method to determine the distances of spiral galaxies has recently been proposed by R. B. Tully and J. R. Fisher (to be published in *Astronomy and Astrophysics*, 1976). Their method is remarkable for two reasons: (1) it uses a distance-independent parameter which is measured at radio wavelengths (21 cm); so far radio astronomy has been slow in providing good distance determinations; and (2) the parameter correlates with the total optical luminosity of a spiral galaxy; up to now only few, if any, luminosity indicators, besides van den Bergh's luminosity classification, have been known for spiral galaxies.

Professor Gustav Tammann of the University of Basel, Switzerland, is presently spending part of his time with the ESO Scientific Group in Geneva as associate astronomer. He is well known for his work on the extragalactic distance scale, culminating in a recent, but already classical series of papers in the Astrophysical Journal, *under joint authorship with Dr. Allan Sandage of the Hale Observatories. We are delighted to bring here the very latest news about the recently discovered 21-cm-line galaxy luminosity (and thus distance) indicator.*

The new method uses the line width of the 21-cm line of external galaxies as measured with single-dish radio telescopes. The width of the Doppler-broadened line is determined by the internal motion of the neutral hydrogen, i.e. essentially by the rotation of the galaxy. Hence, the total line width is expected to be equal to $2 \cdot v_{max}$, where v_{max} is the maximum rotational velocity. Of course the line width can only be determined for galaxies with well-determined 21-cm-line profiles, and this limits the method to spiral and late-type irregular galaxies. It is also evident that the line width reflects only the component of v_{max} in the line of sight; the *true* line width, denoted Δv_{21}^{i}, is directly observable only in edge-on galaxies—the measured line width of other galaxies must be corrected for the inclination i between the rotation axis and the line of sight (by dividing by



The correlation between the absolute photographic magnitude $M_{pg}^{o,i}$ (corrected for absorption in our Galaxy and within the external galaxy) and $\log \Delta v_{21}^{i}$ (the inclination-corrected 21-cm line width) for galaxies with independently-known distances (from Sandage and Tamman, 1976). Spirals of different types are shown with different symbols. The error bars indicate the observational uncertainties of Δv_{21}^{i}.

sin i). Since the correction becomes very large for nearly face-on galaxies, their true line width cannot be reliably determined.

Some correlation between the true line width Δv_{21}^{i} and the optical absolute magnitude M of a galaxy is expected: the line width is correlated with the rotation velocity of a disc galaxy and hence with its mass, and the mass of a galaxy determines to a large extent its luminosity. The only surprising result is that Tully and Fisher found such a tight correlation between line width and absolute magnitude in spite of the fact that other independent parameters were neglected—parameters which are expected to influence as well the mass and luminosity (like the radial distance of the point where v_{max} occurs, the form of the rotation curve, and the subtype of the spiral galaxy). Thus the theoretical background of the correlation is not yet understood, but the good empirical correlation between Δv_{21}^{i} and M suggests that it should be used as a tool to determine distances.

Tully's and Fisher's main result was a confirmation (to within ±10 per cent) of the distances to the M 81 and M 101 groups of galaxies, which formed the basis for the new value of the Hubble constant of $H_0 = 55$ km s^{-1} Mpc^{-1}. However, from a few spiral galaxies, which are members of the Virgo cluster, they determined a distance of this cluster of only 13 megaparsec (cf. *Bull. Amer. Astron. Soc.* **7**, 426, 1975), which is in open contradiction with the distance of 20.0 ± 2.0 Mpc indicated by several other good distance indicators. This contradiction seemed to cast considerable doubt on the 21-cm-line method.

In a rediscussion of the Virgo cluster problem, A. Sandage and G. A. Tammann (to be published in *Astrophysical Journal*, November 15, 1976) have used a larger sample of cluster galaxies and have found from the Δv_{21}^{i} data a cluster distance of 19.2 ± 2.0 Mpc. This is now in very good agreement with other distance determinations and with a value of $H_0 = 55$ km s^{-1} Mpc^{-1}.

How can it be explained that the 21-cm distance of the Virgo cluster seemed originally so small? The reason is an additional difficulty: the apparent magnitude of external galaxies is dimmed by the internal absorption of interstellar dust. The amount of internal absorption increases with the inclination angle i. For nearly edge-on galaxies the magnitude correction is very large (more than one magnitude), but actually the exact amount is still poorly known. Thus the above-mentioned advantage of edge-on galaxies for the determination of the true 21-cm line width is offset by their large and uncertain correction for internal absorption. It seems therefore that galaxies with intermediate inclination ($30° \lesssim i \lesssim 70°$) should be given the highest weight.

The new empirical correlation between the 21-cm line width and the optical luminosity of favourably inclined spiral galaxies already seems to provide a valuable check of the extragalactic distance scale, which is characterized by a Hubble constant of 55 km s^{-1} Mpc^{-1}. Once the theoretical background of the correlation shall be better understood, and accurate determinations of the inclination angle and of the internal absorption shall become possible, 21-cm line widths may become a major route to the distances of many late-type field galaxies. This would be yet another example for the prolific interaction between radio and optical observations.

STAFF MOVEMENTS

Since the last issue of the "Messenger", the following staff movements have taken place:

ARRIVALS

Munich

Marianne Fischer, German, secretary
Hannelore Heubes, German, clerk-typist
Lindsay Holloway, British, clerk-shorthand typist
Martin Hoffmann-Remy, German, accountant
Imke Heidtmann, Swedish, clerk-typist

Geneva

Walter Nees, German, technical assistant
Jacques Ottaviani, French, laboratory technician

Chile

Max Jean Lizot, French, optical engineer

DEPARTURES

Hamburg

Petrus Huijmans, Dutch, finance officer
Gladys Wastavino, German, clerk-typist
Ulrike Schütz, German, secretary
Ingrid Knoth, German, administrative assistant
Brenda Bülow, British, secretary
Heinz-Werner Marck, German, accountant

Chile

Emile Leroy, Belgian, senior engineer
Martin de Groot, Dutch, astronomer
Horst Franz, German, engineer
Lennart Ulltjärn, Swedish, programmer
André Theisen, Belgian, personnel officer

The ESO Administration now in Munich

On July 1, 1976 the ESO Office of the Director-General was transferred from Hamburg-Bergedorf to Garching near Munich, about two kilometres from the site reserved for the construction of the European Headquarters of the Organization. (See "The Messenger" No. 4, March 1976).

When the ESO Council at its December meeting last year accepted the German Government's offer of a site and building for the future headquarters of the Organization at Garching near Munich, hardly anyone of the Hamburg staff thought that he would be in Munich only half a year later.

But the decision to transfer the Office of the Director-General to Garching was taken without delay. Already in February the staff was officially informed that the Administration would move to Garching towards the middle of the year. The decision for this move—before the construction of the headquarters had even started—was mainly taken in order to be on the spot during the construction activities and to improve communications with Geneva. Also, when in 1979 the ESO departments in Geneva in their turn move to Garching, the Administration will be in a better position to assist them and to facilitate a smooth continuation of activities. Most staff members saw no difficulty in following the Administration and began immediately to search for suitable accommodation. The many possibilities for sports and excursions in the surroundings of Munich will partly compensate them for the separation from their relatives and friends in Hamburg. A few staff members were unfortunately not able to follow the Organization and decided to stay in Hamburg.

The removal of the Office of the Director-General took place between June 24 and 30, and most staff members managed to have their private removal done during the same period.

On July 1, the Office of the Director-General resumed its activities and everybody has been working hard ever since to make up for the time lost during the removal period. The staff members who decided to stay in Hamburg have meanwhile been replaced and business operations have now returned to normal.