IS THE HUBBLE TYPE OF A DISK SYSTEM ESSENTIALLY DETERMINED BY ONE PARAMETER: TOTAL MASS?

R. Brent Tully
Institute for Astronomy, University of Hawaii

The contentious title of this discourse was chosen to draw attention to some ideas expressed in a recent publication by Tully, Mould, and Aaronson (1982, hereafter TMA). Two important correlations were discussed in that article. One of those was a correlation between the colors and the intrinsic luminosities or magnitudes of spiral galaxies. The other was a relationship between the color and total mass of disk systems. It is now reasonably accepted that there is also a tight connection between luminosity and total mass.

The color that I refer to is a construct of observations in blue (B_T) and infrared ($H_{-0.5}$) passbands: hence it is sensitive to differences between young and old populations. When I speak of total mass, it is really the deprojected global HI line profile (W_{20}) which is the observed parameter. I take some licence with the implication of a close association between total mass and profile width, but it is the tightness of the luminosity-profile width correlation which encourages me to do so.

The claim is that, for gas-rich disk galaxies, we have good correlations between each pair of the triad: mass, luminosity, and color. One can ask if there is any additional information in the morphological classification of individual galaxies, in the sense that part of the scatter in these relations might be due to systematic variations with type. It can be seen in the review by Rubin at this conference that she and others are impressed by the differences in certain of the above-mentioned relations that depend on the morphological type. By contrast, I am impressed by the lack of differences.

Certainly, this is not to say that we believe there are no differences at all. The galaxies of type Sa-Sb do seem to deviate from the later types in the color-mass relationship demonstrated by TMA, in the sense that the early systems of a given mass are redder. From the mass-luminosity relations, it would seem that most of the type variations are in the blue passband. However, in the samples that we

E. Athanassoula (ed.), Internal Kinematics and Dynamics of Galaxies, 373–374.

https://doi.org/10.1017/S0074180900033295 Published online by Cambridge University Press

accumulated the variations are small; substantially smaller than those found in the samples employed by Rubin and her collaborators, for example. The color-mass (profile width) diagram is particularly useful in the investigation of type-variations because the observables are distance independent so a large and coherent sample can be assembled. In this diagram, as in the plots of luminosity-mass and luminosity-color, the evidence for type variations are marginal.

There is a qualification which might be important from the standpoint of the debate over type dependences. As one reaches the very earliest disk systems, distinctions in the color-luminosity-mass plots become apparent. There is a striking separation between lenticulars and spirals on the color-magnitude diagram in TMA. Huchtmeier has demonstrated the clear separation of Sa systems from later types in the (blue) luminosity-mass plane. It was proposed in TMA that disk systems are disposed to lie in either of two distinct branches in the color-magnitude diagram: either in a branch reserved for gas-rich spirals and irregulars or in one delineated by gas-poor lenticulars. Star formation is continuing in one branch but has essentially stopped in the other.

It remains to be resolved whether the Sa systems lie in the gas-rich or the gas-poor branch, or somewhere between. We have not been able to address that problem properly because early systems are difficult to detect in HI and because the Sa class is poorly represented in volume-limited samples. In summary, it seems probable that gas-poor systems have very distinct color-luminosity-mass properties from gas-rich systems, though the demarcation point between these two regimes is not well explored. At the same time, there are surely other galaxies with anomalous color-mass-luminosity combinations, such as the extreme low surface brightness spirals.

The proposition that is offered is that a gas-rich disk system with a given amount of mass knows how luminous it should be and what dimension it should have (the original correlations discussed by myself and Fisher), what global color it should have (TMA), and how centrally condensed its mass should be (Rubin and collaborators have demonstrated the trend of central velocity gradients with maximum rotation). In TMA, we presented a simple model as an explanation of the color-magnitude relationship. In the model, the total mass governs the galactic star formation rate and must also affect either the galactic metallicity or stellar initial mass function. These properties might be regulated by the amplitude of streaming motions and thus be tied to the dynamics of the galaxy. The amplitude of rotational motions, the scale of the system, the vigor of current star formation in contrast with its past history; these properties must produce consequences which are interpreted in the morphology of a galaxy.

Tully, R.B., Mould, J., and Aaronson, M.: 1982, Ap.J. 257, 527.