UGC 2885, the Largest Known Spiral Galaxy

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How large a galaxy appears in a telescope or on a photographic plate, (what we call its angular size) depends on two factors: its distance and its intrinsic linear size. Until recently, astronomers generally did not describe galaxies in terms of their linear dimensions, due to uncertainties in determining their distances. But recent studies have shown that galaxies come in an enormous range of diameters, and to ignore this range is to neglect one of the few galaxy parameters which can be evaluated. For UGC 2885 (galaxy number 2885 in the Uppsala General Catalogue of 12,921 galaxies in the northern equatorial hemisphere, compiled by Peter Nilson) its diameter is its claim to fame: it is 250,000 parsecs (almost 1 million light years) wide, making it the spiral galaxy with the largest known diameter (Fig. 1).

On the sky, UGC 2885 appears to be about 5.5 minutes of arc across, or as large as the spiral galaxies nearest to our own. However, its redshift is five times as large as the redshifts for spirals in Virgo, making it five times as far away, and five times as large. Both by its position on the sky and its redshift, it is identified as a suburban member of the extended Perseus Supercluster of galaxies, with a velocity of recession near 6000 km per sec. Because we view UGC 2885 in a direction not far from the plane of our Galaxy, it is obscured by the interstellar gas and dust within our Galaxy. Hence it is possible that its true dimensions are even larger than those deduced.

UGC 2885 is an attractive two-armed spiral with a small bright nucleus which appears almost stellar, and with bright emission knots observed even near the extremities of its arms. The presence of these ionized gas clouds surrounding hot, young stars implies that normal star formation is going

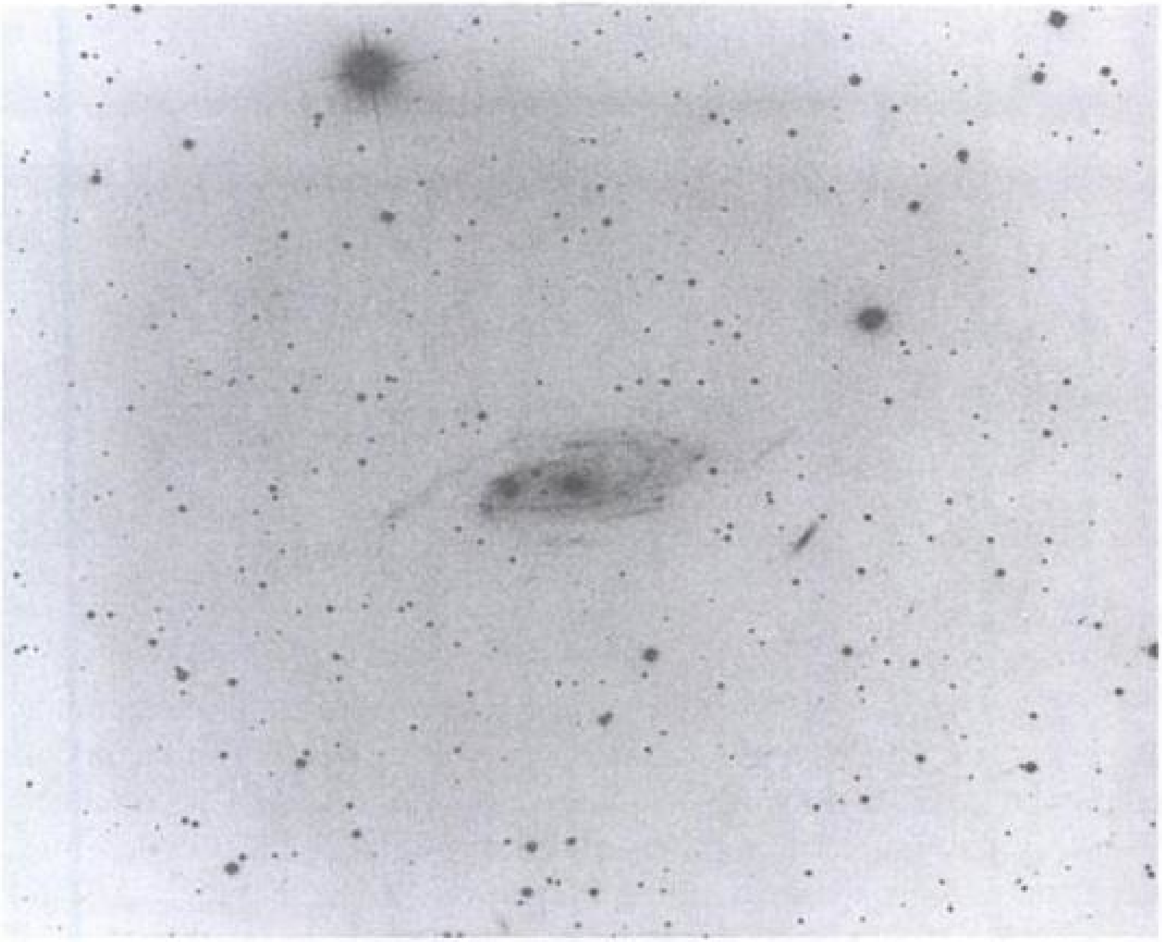

Figure 1. *A negative print of the galaxy UGC 2885 reproduced from a plate taken by Bruce Carney at the Kitt Peak 4-meter telescope. It is a 30-minute exposure on a IIa-O plate through a GG385 filter.*

on even at these large distances from its nucleus. Moreover, the chemical abundances in the distant regions do not appear remarkably unusual. Active star formation at such extreme distances from the nucleus is surprising in comparison with our own galaxy, where astronomers have traditionally concluded that star formation ceases at distances beyond the orbit of our Sun, about 10,000 parsecs.

It is its internal dynamics, coupled with its enormous size, that makes UGC 2885 remarkable. As in all disk galaxies, the stars and gas in UGC 2885 are orbiting the nucleus in circular paths. For UGC 2885, circular velocities are near 250 km per second just beyond the nucleus, and increase to near 280 km per second at the limits of the optical image.[a] Rota-

[a] Here, "limits" of the image means that the surface brightness has fallen to 25th magnitude per square arc second, a convenient measure for discussing the outer brightness of galaxies. All dimensions are calculated using a Hubble constant of 50 km per second per Megaparsec.

tional velocities remain high in all disk galaxies because of the presence of significant mass at large distances from the nucleus. This means that the mass is not centrally condensed in a disk galaxy, as it is, for example, in the solar system. In the solar system, rotational velocities decrease with increasing distance from the Sun: Mercury, at 0.39AU, orbits the Sun with a velocity of 47.9 km per second, while Pluto, 100 times farther at 39.5AU, orbits with a velocity one-tenth as large, 4.74 km per second. This Keplerian decrease in velocity (so called because its basic mathematical form was first described by Kepler) arises because essentially all of the mass in the solar system is located in the Sun. In contrast, the lack of any decrease in stellar velocities for stars at large distances from the nucleus in a disk galaxy tells us that the mass density is falling very slowly; so slowly that the total mass within the galaxy is not converging to a limiting mass at the limit of the optical galaxy. Still more mass, in the form of dark matter, must exist beyond the luminous galaxy. By dark matter we mean matter whose luminosity, per unit mass, is much lower than the normal stellar material. For extragalactic observers, determining the distribution (halo? disk?) and the physics (mini-black holes? Jupiters? bricks?) and studying the dynamics of this matter is an important future goal.

For UGC 2885, the rotation period is 2 billion years at a distance of 125,000 parsecs from the nucleus. The outer regions have therefore undergone fewer than 10 revolutions since the origin of the Universe. (This number is independent of the choice for the Hubble constant, for both the age of the Universe and the linear dimensions of the galaxy scale inversely with the Hubble constant.) Yet with even so few rotations, the arms are smooth and well developed, and there are no large-scale irregularities in the velocity field (or flow pattern) of the galaxy. Large-scale velocity regularity coupled with few revolutions means that a well-ordered global spiral pattern must be established soon after galaxy formation. It cannot be the product of smoothing introduced by many differential rotations. Hence large disk galaxies with global spiral patterns, such as UGC 2885, put important constraints on models of galaxy formation and evolution.

The mass within the optical image of UGC 2885 is about 2 trillion times the mass of our Sun. This is as great a mass as is known for any spiral galaxy. The total mass, the sum of the luminous matter and the nonluminous matter beyond the optical image, is unknown. But judging from the surprises which astronomers have uncovered in their studies of spiral galaxies, much more remains to be learned before we can state with certainty how the total mass is distributed in this or any other galaxy.