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REMINISCES OF “THE MASSES OF SPHERICAL GALAXIES M32, A LIKELY APPLICATION” BY POVEDA (1958)

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RESUMEN

Este documento, en forma de entrevista, contiene los elementos donde Poveda describe la gestación del artículo “The Masses of Spherical Galaxies M32, a likely Application”, 1958, BOTT, 2, 17, 3.

ABSTRACT

This article contains the elements in the form of an interview, where Poveda describes the gestation of the paper “The Masses of Spherical Galaxies M32, a likely Application”, 1958, BOTT, 2, 17, 3.

Key Words: galaxies: kinematics and dynamics

“Look, Omar, what I want to say about this article that I wrote in 1958 (Poveda 1958a), is the following”. This is how Arcadio Poveda started one of the enjoyable conversations over lunch that we’ve been having recently. Poveda is now on his early 80s, but he is as active as ever, evermore curious. He paused for some seconds, his mischievous eyes were looking at the ceiling, while his arms were waving in the air as if conducting an orchestra. He continued, “I was at a seminar where Prof. Martin Schwarzschild (1954), the son of the great Karl Schwarzschild, was presenting some results on the masses of galaxies. He had analyzed Andromeda galaxy spectra reported by Mayall (1951). Schwarzschild noticed an asymmetry in velocity of M31 and attributed it to the gravitational pull of M32. Using this argument, Schwarzschild made a rough estimate assuming $\Delta V = gt$ where $g = GM/d^2$ is the acceleration due to M32’s gravity, t is the time of interaction, M is the mass of M32, $d = 8000$ pc is the distance to the perturbed region, $\Delta V = 80$ km s^{-1}, and t was estimated to be 5×10^7 years; from this information, Schwarzschild reported a mass $M = 2.5 \times 10^{10}\ M_\odot$ for M32. I recall that Lyman Spitzer was also in the audience supporting Martin’s idea. Nevertheless, I was dissatisfied with this estimate, I was uncomfortable...” “You felt something like a stomach ache”, I interjected. “I was in pain, my gut feeling said that something wasn’t quite right”, he assented with his soft-deep tone, pausing for a few seconds, and concentrating his thoughts. Then, he continued with his story. “When I came back to Mexico after finishing my Ph.D. studies at Berkeley, I used to sit in Dr. Paris Pismis’s seminars. I happened to be present the day she introduced the virial theorem. I was immediately hooked on it, such a powerful idea was addictive, such simplicity was almost poetic. I knew I had to do something with it”. “Do you know that it was Sir Arthur Eddington who introduced the virial Theorem to Astronomy in 1916”, I interrupted. “Yes”, Poveda said, “he applied it to stellar systems[2]. However, the virial Theorem was originally introduced to statistical mechanics by Clausius”. “Then Albert Einstein wrote a paper in 1921 suggesting an application to measure the mass of globular clusters.” “I sent you a copy of his paper a while ago” I exclaimed. Poveda assented “I got the paper that you sent me, thank you, Einstein was an incredible scientist, his mind was astonishingly powerful and penetrating”. Poveda continued “You must know that during those years, late 1950s, it was very easy to keep up with the literature, and learn about any new development in astronomy. I was reading the Director’s report from the Mt. Wilson and Palomar Observatories, I believe that Ira S. Bowen (1954) was the director. I found there that Rudolf Minkowski had measured the velocity dispersion of a few galaxies, he even reported the numbers highlighting the spectroscopic developments at the observatories. I mentioned this reference in my article. Then, I learned about the de Vaucouleurs profile from an article published in 1953 (de Vaucouleurs 1953)”. Poveda’s eyes grew wider and exclaimed “Oh, gosh, I had everything: the virial theorem, the velocity dispersion for M32, and the radial surface brightness distribution (expanded into an article in Poveda et al. 1960). I combined these three elements

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[2]Although, it was Jules Henry Poincaré (1911) who introduced the virial theorem to analyze a swarm of a meteorites.

and I arrived at the formula, which has been called the 'Poveda Formula'. This expression combines the angular size a (in arc sec) and the velocity dispersion σ. Then, the total mass of a spherical galaxy in steady state whose surface brightness distributions follows a de Vaucouleurs profiles is given by":

$$M = 3a\sigma^2/G$$

"But you knew that Zwicky had applied the virial theorem to determine the mass of the Coma cluster in 1937 (Zwicky 1937)" I interjected. "Yes, of course I was aware of Zwicky's result. I had to show that elliptical galaxies do not follow a polytropic sphere of degree $n = 5$, as Chandrasekhar (1939) had suggested in his very famous monograph. Chandrasekhar wrote that the potential energy of a polytropic sphere of degree $n = 5$ was infinite. Spitzer said the contrary, but didn't provide an estimate. I wrote a companion paper (Poveda 1958b) to the one on the masses, where I showed that a polytropic sphere of degree $n = 5$ provided a poor fit to elliptical galaxies, that the potential energy was finite, and calculated its value[3]. I never came back to the subject. Data on galaxies were really scarce at that time. Besides, It was also hard for me to obtain observational data. I having been trained as a theoretician, found it difficult to conduct observations in Tonantzintla. My colleagues, the observers, used to make the operation of the Schmidt Camera seem like a really involved and complicated task. So I was discouraged to do my own observations. It was until much later, when Harold Johnson came to work at the Instituto de Astronomía that I finally understood the craft of astronomical observing. This experience with Harold helped me a great deal during the construction of the Observatorio Astronómico Nacional in San Pedro Mártir in the late 1970s." Poveda, closed "I was very lucky to be in the right place, at the right time".

The afternoon continued, with delicious desserts and some fine drinks. We changed the subject of our conversation. It was a very pleasant afternoon in Mexico City. Outside the traffic moved fast and erratic; inside, we were still talking about the fun of doing research. Poveda has not lowered the pace of his excitement. Poveda's driver came to pick him up. We said good bye, and I returned to Puebla, adjusting my mind to all that the dean of Mexican astronomy had just told me.

The value for M32 mass derived by Poveda (1958a) was $M = 5 \times 10^8\ M_\odot$; this value has been

[3]In the Dover edition of Chandrasekhar text it now reads that the potential energy is finite but, its extension is infinite.

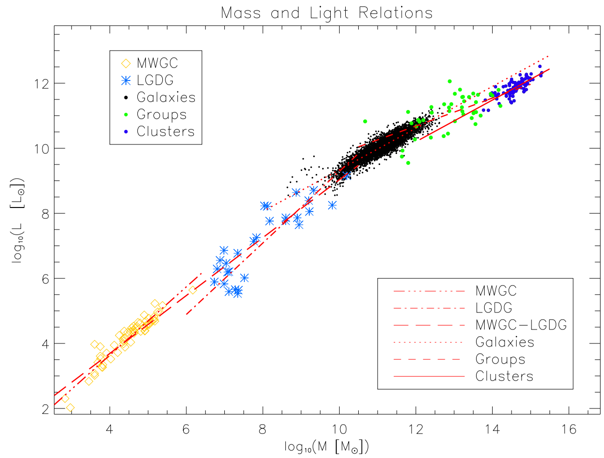

Fig. 1. Ibarra-Medel & López-Cruz (2011) have obtained the $\mathcal{M} - \mathcal{L}$ relations for globular clusters, dwarf galaxies, early-type galaxies in clusters and the field, groups of galaxies and clusters of galaxies. They found changes in the slope of the fundamental plane along the different scales; furthermore, they noted a continuity across all the scales covered from globular cluster up to clusters of galaxies.

corroborated by the SAURON collaboration (Capellari 2006). They have used an integral field unit to map the velocity fields in nearby early type galaxies, the surface brightness distribution has been modeled using a non-parametric approach. Indeed, the simplicity of a powerful idea brings great precision.

These results have not passed unnoticed. Poveda's (1958a) paper was cited by King (1963) Annual Review's article. It guided the galaxy mass estimates by Burbidge & Burbidge (1975). It also served Djorgovski & Davis (1987) seminal work where they introduced the fundamental plane for early-type galaxies.

How is the Poveda Formula doing? The virial theorem rests on the conservation of energy for dynamical systems in steady state or quasi-steady state. It has been extended into the fields of relativity and quantum mechanics. State of the art instrumentation is providing us with kinematical data on galaxies, which allow very detail modeling. However, results derived with the aid of the virial theorem keep on being valid with a high degree of accuracy (e.g., Capellari 2006).

Recently, Ibarra-Medel & López-Cruz (2011) have extended the analysis of Poveda (1958a) to globular clusters, dwarf galaxies,early-type galaxies in clusters and the field, groups of galaxies, and galaxy clusters (Figure 1). The range of the data covers about 11 orders of magnitude in mass and about 10 orders of magnitude in luminosity. This also proves that the virial theorem is scale invariant. This results confirms Poveda's feelings about the simplicity and power of the virial theorem.

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