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Conference Highlights

Galaxy Disks and Disk Galaxies[1]

The conference "Galaxy Disks and Disk Galaxies," sponsored by the Vatican Observatory, was held in 2000 June at the Pontifical Gregorian University, in the very center of Rome. The meeting hosted about 230 participants from 30 countries. Social events included a visit to the Vatican Observatory and the Papal Villas at Castel Gandolfo. A buffet supper was served on one of the terraces of the Papal Summer Residence, where the Vatican Observatory is located. The very full program consisted of 29 review papers, 34 invited talks, and more than 180 posters. The meeting covered topics regarding the structure, formation, and evolution of galaxies with disks. Particular attention was dedicated to the stellar and gaseous disk of the Milky Way, the global characteristics of galaxy disks, their structure, morphology and dynamics, the gaseous components, star formation, and chemical evolution, the interactions, accretion, mergers and starbursts, the dark and luminous matter, the establishment of the scaling laws, and the formation and evolution of disk galaxies from a theoretical and observational point of view.

New observational evidences constraining the star formation and merging history of the Galaxy were presented. There was a broad consensus about the mass distribution of the Milky Way. Near-infrared data show that the Galactic bar extends to about 4 kpc while the terminal curve, the Oort limit, and the bulge microlensing observations together favor the idea of a massive and near-maximal disk. The vertical structure of the Galactic disk, and in particular the origins of heating, was explored from both empirical and theoretical points of view. A new composite CO survey provided a nearly complete inventory of giant molecular clouds, which are one of the main sources for disk heating. The correlation between the thickening of the Galactic disk, its stability, and the fraction of the total mass to be attributed to the Galactic halo have been taken into account, and tidal tails from satellites have been used to probe the gravitational potential. Chemical abundances and abundance ratios derived for the Galactic disk impose strong constraints on its formation and evolution, and they indicate an inside-out process of growth which is still ongoing.

Analysis of the surface photometry of a sample of around 750 early-type galaxies reveals that elliptical galaxies also have disks, suggesting that all galaxies were either born with, or later acquired, disks. The scaling relations of typical disks in ellipticals smoothly join those of spiral and S0 disks, even if some marked differences do exist for disks deeply embedded in spheroids. New K-band images show that the morphological structure of disk galaxies differs from that observed at shorter wavelengths; in particular, the decoupling between the stellar and the gaseous disks can be dramatic. In any event, the coexistence of radically different morphologies within the same galaxy can be explained naturally by the modal theory of spiral structure. Large-scale magnetic fields, remarkable in their extent and close correlation with the spiral arms, have been detected in the disks of all nearby galaxies. Sometimes they show vertical orientation suggesting field closure through the halo. Their origins have been interpreted in terms of a multimode dynamo theory.

Theoretical efforts that take into account the dynamical processes in self-gravitating disks have been made in order to explain the large spiral structure observed in the optical and the near-infrared. The role of spiral arms and bars in driving the evolution of disks was also discussed, showing that we now have a mature theory of disk instability. The secular evolution of disks proceeds through self-regulation and feedback mechanisms. Dynamical modeling has benefited greatly from the unique capabilities of integral field spectroscopy. Observation of external galaxies suggests that the dominant heating mechanism varies along the Hubble sequence and has shown the existence of cyclones and anticyclones in gaseous disks. An update of the correlation between black hole mass and the mass of the host spheroidal component was presented (the black hole mass fraction is $\sim 0.17\%$). It also appears that the black hole mass is even more strongly correlated with the stellar velocity dispersion of the host galaxy. This new result corroborates the idea that black holes, quasars, and bulges grew and turned on as parts of the same process.

Neutral hydrogen in and around some 200 spiral and irregular galaxies has now been mapped with the WHISP survey. The H I disks are more extended than the corresponding optical disks and show a wider variety of features such as debris of tidal interactions, warps, lopsidedness, spiral arms, and even bar-shaped structures. Although H I

[1] Conference was held in Rome, Italy, at the Pontifical Gregorian University on 2000 June 12–16. Proceedings will be edited by J. G. Funes, S.J., and E. M. Corsini and published in the ASP Conference Series.

structures are rare in giant elliptical galaxies, they appear to be more common in low-luminosity systems. Their morphology ranges from chaotic, through loops and rings, to still-growing disks with surprisingly regular kinematics. New interferometric surveys have enhanced our knowledge of the distribution and kinematics of molecular gas on subkiloparsec scales, and impressive *Chandra* pictures unveiled the violent side of the interstellar medium (ISM) by mapping the hot gaseous component in nearby galaxies. Characterizing the demographics and quantifying the spatial variation of the star-forming galaxy population, as well as probing the dependence of the local star formation rate on the properties and dynamics of the ISM, turned out to be hot topics for a detailed understanding of star formation in galaxy disks. Their most luminous H II regions seems to be density bounded and responsible for half of the Hα emission in normal disks.

Great emphasis was given to the role played by galaxy interactions and mergers in the nearby universe, and even more so in the early universe, where galaxies appear to be far from equilibrium. Numerical simulations are widely used to explore the merging processes driving morphological transformations and show that low-luminosity fast-rotating ellipticals are not formed as by-products of collisionless mergers of unequal-mass disk galaxies. Beyond this, a complete picture of the role and the fate of gas has not yet been produced, and it deserves further investigation. Extended disks form by accreting material from the environment and are often warped, most probably due to a continuously maintained misalignment between the angular momenta of the galaxy and its halo. A large fraction of spirals exhibit kinematic disturbances ranging from mild to major and can generally be explained as the visible signs of tidal encounters. Planetary nebulae around ellipticals can be used to trace the gravitational potential and interactions with the surrounding cluster. Gravitational interactions are also likely to be the main mechanism for both the transformation of cluster spirals into S0s and the fueling of gas into the center of the encounter partners, thus triggering star formation.

New combined optical and radio rotation curves were presented for both high and low surface brightness spirals. They were used to derive mass models and constrain the size of dark halos. Low surface brightness and dwarf galaxies are dominated by dark matter, in agreement with early results based on H I data alone. Closer to us, the kinematics of the LMC is consistent with a truncated, finite-thickness exponential disk model with no dark halo. The origin of scaling laws related to the structural properties of disk galaxies were discussed with the help of high-resolution gasdynamical simulations and semianalytic models, and a lively debate arose on the controversy about the relative fraction of luminous to dark matter inside the optical region of spirals. Observational evidence, modeling results, and theoretical considerations were provided for and against the idea that stellar disks contribute a maximal rotational support in the inner parts of galaxies. Two of the most promising developments presented were the discovery of rapidly rotating bars through the direct measurement of their pattern speed and the better agreement between the predicted and observed Tully-Fisher zero point obtained by semianalytical modelers through a proper choice of the initial power spectrum.

General agreement on the scheme for galaxy formation based on hierarchical clustering and mergers was the strongest point of convergence of the meeting. The formation of bulged galaxies is a problem which has been essentially resolved. Large bulges are assembled by mergers of subclumps, formed from gas cooled in the center of dark halos, and then acquire their disks, while small bulges are most probably the result of disk secular evolution. The formation of pure-disk galaxies still remains an open question which must be addressed. New ideas have focused on the formation and structure of dark matter halos, including their density and angular momentum profiles, abundance, and merging rates. Evidence supporting the idea that damped Lyα systems observed at $z \sim 3$ are the direct progenitors of the current thick disks in galaxies was discussed, and there were indications that some extremely red objects at high redshift are disks. The chemical history of Local Group galaxies has been used to infer the nature and evolutionary status of higher redshift objects, and new spectrophotometric codes are now available to follow galaxy evolution and to constrain cosmic star formation history.

As pointed out in the Conference Summary, galaxies are the crossroads of astronomy because they look up to cosmology and they look down to the interstellar medium and star formation. This meeting highlighted the points of convergence in our comprehension of the formation and properties of disk galaxies, suggesting at the same time that the future challenges in this field are to make those connections (such as between the properties of hydrodynamical models and those of real galaxies or between a physically based theory of star formation and what is observed in galaxies) that at the moment we have failed to make.

José G. Funes, S.J., and Enrico Maria Corsini
Vatican Observatory, Università di Padova