

COMMISSION 28: GALAXIES (GALAXIES)

Report of meetings 20, 21, 22, 23, 25, 26 and 27 November 1985

PRESIDENT: V.C. Rubin

SECRETARY: P.C. van der Kruit

Commission 28 was involved in three all-day Joint Discussions, of which the proceedings will be published in Highlights of Astronomy, volume 7: Radio Astronomy and Cosmology (Commission 28, 40, 47), 21 November, Evolution in Young Populations in Galaxies (Commissions 25, 28, 33, 34, 37, 45), 26 November, Supernovae (Commissions 27, 28, 34, 35, 40, 44, 47, 48), 27 November. Two sessions were held jointly with other commissions: Stellar Orbits and Structure and Evolution of Galaxies (with Commission 33) on 22 November and Galaxy Radial Velocities (with Commission 30) on 20 November. Ten sessions were held by commission 28 alone. Programs of these and abstracts of some of the papers follow below. The session on Galaxy Radial Velocities is covered in the report of Commission 30.

20 November: Business and Working Group on Internal Motions

CHAIR: V.C. Rubin

The following items were covered in the business session:

New officers: the commission unanimously elected P.C. van der Kruit as the new president and G.A. Tammann as the new vice-president. Outgoing members of the Organizing Committee are J.A. Graham, P.W. Hodge, M.-H. Ulrich-Demoulin and B.E. Westerlund, who were thanked for their contribution. Elected for a second term were S.d'Odorico, J. Einasto, I.D. Karachentsev, D. Lynden-Bell, A. Toomre and K.-I. Wakamatsu. The outgoing president V.C. Rubin was also elected for an additional term. Newly elected members are E. Khachikian, Li Qi-Bin, J. Lequeux and H. Quintana.

New members: A total of 117 names of new members were proposed before and during the General Assembly and one of a consultant. These were admitted. Commission 28 now has 473 members and 1 consultant. Some attendants urged the new president to ask non-active members to resign and so reduce the membership.

Draft report: A member of participants indicated the usefulness of the report. It was subsequently adopted.

Working groups: The WG on Internal Motions needs a new chairperson. Names were proposed during the General Assembly upon the president's request. After the General Assembly C.J. Peterson was appointed.

Resolutions: None

Other business: The members were informed on the other meetings of Commission 28 during the General Assembly.

In the scientific session of the Working Group on Internal Motions the following papers were presented:

J.S. Gallagher (USA): Echelle measurements of emission line kinematics in galaxies

R. Giovanelli (USA): UGC 12591 - the most rapidly rotating disk galaxy.

A. Sandquist (Sweden): ^{12}CO in NGC 1365 and M31.

M.A. Kazaryan (USSR): Spectra of active galaxies including Seyfert, narrow-line galaxies and absorption-emission line systems observed with the 2.6m Byurakan and USSR 6m telescopes.

Gallagher:

The echelle spectograph on the Kitt Peak Mayall 4-m telescope has enabled observations to be obtained for emission lines with FWHM velocity resolutions of 12-30 km/s. Results are briefly reviewed from programs to study Sc spiral nuclei, Seyfert galaxies with extended radio emission, and diffuse ionized gas in blue irregular galaxies. These show that the echelle data provide improved precision in determining velocity field from line centroids and furthermore reveal a variety of local kinematic anomalies through the line profiles. For example, in the M51 nuclear region disturbed gas with "nuclear" emission characteristics extends over the inner ~ 1 kpc and in blue galaxies disturbed velocity fields are associated with ionized filaments and may be due to energy input from young stars.

Giovanelli:

Work done in collaboration with M.P. Haynes and V. Rubin. Arecibo 21cm observations of the Soa galaxy UGC 12591 exhibit a line profile with a width of about 1000 km/s, the broadest ever observed. The radio observations are corroborated by an optical rotation curve ($H\alpha + [N II]$) obtained at the 5m telescope on Mt. Palomar. The total mass within R(25) inferred from the rotation curve is $2 \times 10^{12} M_{\odot}$. Implications on the mass-rotational velocity relation, luminosity-linewidth relation and the gas content of early-type galaxies were discussed.

20 November: Working Group on Space Schmidt Telescopes

CHAIR: F. Bertola

During the business section Dr. Lequeux of Marseille was elected chairman and Dr. K. Henise vice-chairman.

During the scientific section Dr. Lequeux reported on a proposal submitted to ESA in answer to a call for ideas of a small low cost 50cm Cassegrain telescope to be placed on the Eureka platform. Dr. Tovmassian remarked that a similar instrument, especially concerned for studies of galaxies and quasars, called GLAZAR, will be put in orbit soon by the Soviet Union. Dr. R. Barban of Padova, Italy, reported on the work done in Italy for the frame of one meter class Schmidt telescopes. Dr. H. Smith, University of Texas described the situation, which at the present is not promising, in the United States concerning the Space Schmidt. Dr. Heatherthorn of US Naval Observatory described the present status of development of the detectors for Space Schmidt. Dr. Davidson of Johns Hopkins University provides some information on the UIT project.

20 November: Working Group on Supernovae

CHAIR: V. Trimble

Participating members of Commission 28 and other interested IAU Members and Invited Participants agreed (a) that the Working Group should exist; (b) that its membership should consist of the current mailing list (about 120) plus others who desire to join, and (c) that nominations and an election for a vice-chairman should take place during 1986, the vice-chairman to become chairman in the course of the XXth General Assembly in 1988.

After some discussion, participants agreed upon a system of assigning temporary and permanent names to supernovae as they are discovered. This recommendation was endorsed by the General Assembly as Resolution C11 and appears elsewhere in this volume.

In addition to its involvement in the organization of Joint Discussion VII (Supernovae), the Working Group had one session of its own, at which 10 contributed papers were presented. A list of these, with exceedingly brief summaries, follows.

"Some Possible Identification between Chinese Stars and SNR's" Wang Z.-R. (PRC). Seven tentative new associations were suggested, on the basis of approximate positional coincidence and congruence of distance and age. Events date from 832 BCE to 1523 CE, and remnants include some wellknown ones (Kes 25; RCW 103). Confirmation of even one or two of these would enormously increase our understanding of young SNR's.

"Supernova Rates in Flocculent and Grand Design Spirals" M.L. McCall (Canada). Spiral galaxies with and without grand designs attributable to spiral density waves do not differ significantly in their supernova rate or in the proportion of Type II events. The implication is that massive star formation is not much inhibited by the absence of a density wave.

"Gravitational Radiation by a Rotating Stellar Core during Collapse" Yu Y.Q. (PRC). Numerical simulation of the collapse of rotating configurations indicates that gravitational radiation is not very efficient at carrying off angular momentum. This leads to a sort of barrier at $a/M = 1$, and the possibility of formation of naked singularities.

"Supernova and Cosmic Rays" M.M. Shapiro (USA), Production of a substantial fraction of cosmic rays by supernova of Type I may account for many features of their composition and spectra.

"Non-LTE Effects in SNe Photospheres" R. Wehrse (GFR). The color temperature of Type II Supernova at visible wavelengths is typically somewhat higher than the effective temperature, owing to scattering effects. This must be taken into account when measuring SN distances by the Baade-Wesselink method.

"The Jodrell Bank Pulsar Search" F.G. Smith (UK). A search over a wide range of periods and dispersion measures had identified 32 new pulsars with large dispersion measure, indicating distances in the range 5-10 kpc. Most are within 60° of $l = 0^\circ$. Two new young objects with periods near 0.1 sec have slowing-down ages of 22,000 and 17,000 years, filling in the gap between Vela and longer-period objects.

"Contributions of SNR's to the Diffuse X-Ray Background on the Galactic Ridge" K. Koyama (Japan). SNR's are responsible for a significant portion, but probably not all, of this relative smooth background.

"VLBI Observations of the Compact Sources in M82" N. Bartel (USA). About 20 bright sources, unresolved at $0''.15$, have been mapped with the VLA. At least a couple have declined measurably in brightness over 1-2 yr. Many (not the variable ones) have been resolved with VLBI, indicating sizes near 1pc. The shape is never symmetric. They are thus too extended for recent supernovae and too bright (many times Cas A) for intermediate-age remnants and so apparently represent a new class of source.

"Phase Transitions of High Density Matter and Supernova Explosions" K. Sato (Japan). A phase transition to pion condensate, strange quark matter, etc. during gravitational collapse of a stellar core can either weaken or strengthen the outgoing shock needed to produce a supernova explosion. In particular, a strong first-order transition would greatly increase the chances of the shock getting out with sufficient energy.

"Supernova-Induced Star Formation (IRAS Data)" T.N. Rengarajan (USA). A search of the IRAS data base for point sources in the vicinity of known supernova remnants uncovered a significant excess (555 where 389 would be expected), 2/3 associated with six remnants, and most around the edges rather than the centers. Although the remnants (Pup A, W28, IC 443, etc) are relatively old, near 10^4 yr, their ages are still much less than the free-fall collapse time of a protostellar cloud. Thus the excess must reflect the general association of supernova with regions of active star formation, rather than direct causality.

22 November: New Results (2 sessions)

CHAIR: P.C. van der Kruit

The following papers were presented of which some abstracts are included below:

- S. van den Bergh (Canada): RR Lyrae Variables in M31.
 J. Hutchings (Canada): IUE spectra of OB stars in M31 and M33.
 I.A. Issa (Egypt): Distance Estimates of the LMC, SMC and M33 from the apparent radius distribution of HII-regions.
 R. Wielebinski (GFR): Radio continuum - far infrared - blue light correlations in galaxies.
 D.A. Hunter, W. Rice, F. Gillet, J. Gallagher (USA): IRAS observations of irregular galaxies.
 S. Jörsater (ESO): On the nature of spiral arms in spiral galaxies.
 P.O. Lindblad (Sweden): Peculiar gas motions in the nuclear region of NGC 1365.
 G. Rydbeck, A. Hjarmarson, L.E.B. Johansson, O.E.H. Rydbeck (Sweden): Density wave related molecular cloud spiral arms in M51.
 E. Skillman, H. van Woerden (Netherlands): HI observation of dwarf irregulars in the Local Group.
 F. Sakhibov, M.A. Smiznov (USSR): The corotation radius in spiral galaxies with application to M33.
 J. Gallagher, O.A. Hunter, A. Sandage (USA): UVB colors of Virgo cluster irregular galaxies.
 S.D. Mathur (India): Small oscillations of collisionless gravitating systems.
 T. Padmanabhan, M.M. Vasanthi (India): Cosmological scenario with unstable dark matter.
 R. Cowik, S. Ghosh (India): Effect of dark matter on the structure and dynamics of galaxies and galactic clusters.
 M. McAdam (Australia): A radio Head-Tail Source in IC 2082.
 K. Taylor (UK): TAURUS observations of ionized gas in Centaurus A.

Van den Bergh:

Eighteen RR Lyrae Suspects have been found in a halo field 40' from the nucleus of M31. Photometry of 16 CCD frames of this field yields a period of 0.599 ± 0.08 days for the first of these objects that has so far been studied in detail.

Issa:

The size distribution of HII regions in the LMC, SMC and M33 is used to estimate their distances. The values deduced are 42.66 ± 2.51 , 89.73 ± 5.03 and 7.55 ± 47.14 kpc respectively.

Hunter:

Normal, non-interacting irregular galaxies appear to be unusual among actively star-forming galaxies in lacking numerous optically dark nebulae. IRAS data are being used to explore the properties of thermal emission from dust in a sample of irregulars with a range in star formation rates. In general the irregulars are a smooth extension of the spiral galaxies to hotter dust color-temperatures and higher L_{IR}/L_B ratios. No correlation is seen with metallicity. The $L_{IR}/L_{H\alpha}$ ratios are consistent with the bulk of the star formation being optically visible.

Jörsater:

Mosaic Multicolour CCD photometry has been done on a number of large southern barred spirals. The best studied case, NGC 1365, shows a clear difference of colours between the bar and the arms. The arms also contain a red stellar component, but this may be stars rather recently formed in the spiral shock, rather than an actual density wave in the old population. The relatively little shear in the star formation region of the arms is suggested to imply that the intensity of star formation depends on the distance from corotation.

Hjalmarson:

Data from a continuing CO ($J=1-0$) mapping of the dense (molecular) cloud distribution in M51 where presented. Although CO is observed in arm as well as interarm regions there is a pronounced signal enhancement (observed arm-interarm contrast ratio $\sim 2-3$). Streaming in the sense predicted by density wave theory is observed across the arms.

Van Woerden:

Neutral hydrogen distribution and motions in dwarf irregulars in the Local Group have been mapped with the WSRT with ~ 100 pc resolution. Derivation of rotation curves and mass distributions is hampered by noncircular motions in some objects. In Sextans A and Pegasus the velocity dispersions are ~ 8 km/s. Sextans A shows strong HI maxima bordering on young star complexes. Skillman finds a critical surface density of 10×10^{20} atoms/cm² in 4 dwarfs, over 500 pc scales.

Sakhibov:

The observational detection method of the corotation radius based on the analysis of the age gradient in spiral arm starformation complexes is proposed. Direction and velocity of the starformation wave in the complexes depend on the distance from the nucleus of the M33. The corotation radius is $R = 5$ kpc in M33.

Gallagher:

UBV photoelectric photometry has been obtained for 60 irregular galaxies chosen from the Virgo cluster galaxy morphological classifications by Binggeli, Sandage, and Tamman published in the *Astronomical Journal*. Virgo Irrs have a larger spread in color than is found in field Irr samples, which is due to the presence of abnormally red Irr systems and very blue BCDs in Virgo. Red Irr galaxies are concentrated in the galaxy density enhancement associated with NGC 4472 and have an overall spatial distribution like that of the dEs. Irrs with normal colours seen to roughly follow the more extended surface density distribution defined by spirals. The BCDs which are blue (not all are!) are perhaps noteworthy for their spread in radial velocity, as pointed out by Karachentev and colleagues in the USSR.

Complex relationships between galaxy properties and cluster environment parameters thus extend to Irr members of Virgo, but we do not find evidence for hypothesized evolutionary connections between Irr and dE galaxies in clusters.

Mathur:

We investigate the evolution of small perturbations on a stable, equilibrium configuration of a self gravitating collisionless system. Astrophysical applications are for galactic halos and elliptical galaxies. The system is described by the (linearized) collisionless Boltzmann equation. We find that the spectrum of oscillations is absolutely continuous - and all small perturbations mix away (asymptotically) to leave the system in equilibrium. We achieve our results by applying techniques from the theory of linear operators to the evolution operator of the perturbations.

Padmanabhan:

Cosmological scenarios with one unstable heavy neutrino ν_H of mass m_H which decays into a stable light neutrino ν_L of mass m_L , are considered. In the early phase of the universe ν_H dominates the expansion, and density fluctuations in ν_H grow. When ν_L becomes non-relativistic it condenses on to the ν_H potential wells and these perturbations go non-linear. The ν_H decays after this epoch and the decay product ν_L provides the large scale structure in the universe. Consistent scenarios are possible if m_H is in the range of (150-200)eV and m_L is about 10eV and the lifetime of ν_H is about 10^{11} sec.

McAdam:

Radio emission from the source 0427-53 surrounds the 13^m9 IC 2082, a giant cD galaxy with a double nucleus in a cluster of more than 80 giant cD galaxy with a double nucleus in a cluster of more than 80 members. Radio maps at 843 MHz (Molonglo, 43

arcsec beam) and 1415 MHz (Fleurs, 20 arcsec) show a wide angle tail structure and a double head. The midpoint is identified with the fainter optical nucleus which has a velocity of 240 km s^{-1} with respect to the rest of the galaxy and the cluster centre. This nucleus is thus in orbit and not yet captured. The radio tail has a sharp bend 5 arcmin (150 kpc) from the nucleus, suggesting tangential drag in a dark cluster medium with ordered flow.

22 November: Stellar Orbits and Structure and Evolution in Galaxies
(jointly with Commission 33)

CHAIR: L. Martinet

The programme consisted of two parts, in each of which three papers were presented:
a. Information inferred from orbits for studies of structure and evolution in dynamics

L. Martinet (Switzerland): Recent developments in the field—an overview.

T. de Zeeuw (USA): Construction of triaxial galaxies.

A. Wilkinson (UK): Integrals of motion of the stellar orbits in a tri-axial N-body model of an E-galaxy.

b. Other topics in dynamics:

H. de Jonghe (Belgium/USA): On the non-uniqueness of anisotropic distribution functions for spherical systems.

T.R. Bontekoe (Netherlands): Dynamical friction in a binary galaxy model.

Yong Yi (China): The general solutions of Poisson's equation in 3-D for disk-like galaxies and their applications.

The abstracts of these papers are given below.

Martinet:

We review recent results on the orbital structure of perturbed integrable systems, the constraints for equilibrium models of SB galaxies, the sensitivity of irregular orbits to various populations, the advantages of action-angle variables, the importance of the complex instability of periodic orbit in 3-D problems.

De Zeeuw:

The orbits in triaxial elliptical galaxies resemble closely those in the separable potentials first classified by Stackel, for which three exact integrals of motion exist that are explicitly known. It is shown that the existence of more than one basic orbit family ensures that for a given triaxial mass model many phase space distribution functions exist that are consistent with it. This means that the dynamical structure of elliptical galaxies is very rich.

Wilkinson:

The potential of a relaxed n-body model of a triaxial elliptical galaxy can be closely approximated by a Stackel potential. This enables us to determine the orbital content of the model accurately for the first time. The distribution function of the model is also completely known. This enables us to test the equilibrium state of the model, the nature of the distribution function, and yields the phase space density of each crucial type. Fitting a Stackel potential therefore finishes a quick and efficient way of investigating the dynamics of suitable body models.

De Jonghe:

A given spherical mass density allows an infinity of distribution functions depending on energy and total angular momentum. Only one of them is isotropic, but in order to determine a unique distribution function when full anisotropy is allowed, we need all its moments. Consequently, a given mass density together with radial and tangential velocity dispersions do not suffice. This fact is illustrated with a family of distribution functions that yield the well-known Plummer model, for which many of the dynamical variables can be analytically calculated.

Bontekoe:

Numerical experiments simulating the merger between two unequal galaxies yield measurements of the coefficient of dynamical friction. In these simulations the main galaxy consists of 5000 selfgravitating pointmasses, while the satellite galaxy is represented by a constant Plummer potential of 1/10 of the mass and radius of the main galaxy.

In case that the main galaxy is an index 3 polytrope the satellite starts at the outer boundary on a circular orbit. The decay of the satellite orbit is characterized by high values of $\ln \Lambda$ in the outer regions, dropping to a nearly constant value between the 90 and 10 percent mass radius of the main galaxy. This constant value of $\ln \Lambda$ indicates that the dynamical friction process is a local process in the spirit of Chandrasekhar (1943) and thus global responses of the main galaxy, e.g. tides, are dynamically unimportant.

However, in a similar experiment using a King-model as main galaxy we find almost linearly decreasing values of $\ln \Lambda$ with separation of the two galaxies. (In this model the satellite started at the 90 percent mass radius on a circular orbit; the King model has index 1.5). This means that the purely local description, as for the polytrope, is not valid anymore, but we can not explain the fundamental difference. A strictly linear relation between $\ln \Lambda$ and galaxy separation predicts a linear decrease of the galaxy separation with time (see Lin & Tremaine 1983). The thus defined merger time agrees exactly with the time found by our simulation.

In a third experiment the satellite starts at the outer boundary of the King-model with one tenth of the circular velocity. The resulting orbit has an eccentricity 0.99 with the first pericentre at the core radius. The merging process yields no circularisation of the satellite orbit due to dynamical friction. The semi-major axis of the orbital parameters decreases almost linearly with time, whilst the eccentricity remains constant.

Yong Yi:

It is necessary to consider the spiral galaxies in three-dimensional space because they are not infinitely thin disk. Taking the solution of the Poisson equation of infinitely thin disk to be the Green function we will be able to obtain two solutions of the Poisson equation for disk galaxies of finite thickness. One is a rigorous solution from which we can estimate the thickness of spiral galaxies, the other one is a general solution from which we can get the accurate patterns of spiral arms. With the help of the two solutions, we can get the density distribution within galaxies, the gravitational potential of the disk for spiral galaxies and the velocity dispersion distribution of stars within the galaxies, etc.

23 November : Working Group on the Magellanic Clouds (two sessions).**CHAIR: M.W. Feast**

Feast will continue as chairman of the WG, but it was agreed that a small (4 member) committee would be useful. The chairman would arrange for a list of names to be proposed at the next General Assembly.

The following papers were read:

J. Lequeux (France): The ultraviolet extinction in the Magellanic Clouds.

J. Lequeux (France): The kinematics of the Magellanic Clouds.

J. Lequeux (France): C-stars and emission line objects in the SMC.

M.W. Feast (South-Africa): The distances of the Magellanic Clouds.

R. Kraft (USA): The stellar population near NGC 121.

R.D. Cannon (UK): The stellar population in the SMC.

R. Foy (France): The chemical composition of an SMC supergiant.

A. Bianchi (Italy): The ultraviolet extinction in the Magellanic Clouds.

D.J. Helfound (USA): Einstein X-ray results in the LMC.

I. Appenzeller (GFR): B[e] supergiants in the Magellanic Clouds.

A. Preite-Martinez (Italy): SNR's in the LMC.

R. Wielebinski (GFR): Radio continuum from the Magellanic Clouds.

A. Florsch (France): Catalogues of Magellanic Cloud objects. A communication from M.C. Lartet (France) on nomenclature in the Magellanic Clouds was noted.

25 November: Working Group on photometry and spectrophotometry of Galaxies

CHAIR: J.-L. Nieto

i) Report on the activity of the WG during the triennium 1982-1985. About 320 papers were quoted in the WG report published in the IAU Transactions, but a small percentage of them comes from the WG members. A specialized meeting in connection with WG interests, entitled 'New aspects of Galaxy Photometry', was organised in Toulouse (France) in September 1984, five years after the Austin meeting.

ii) Continuity of the WG as such and membership. It was suggested to try to open the WG to colleagues very active in the field of IR and UV Photometry and Spectrophotometry.

iii) Dr. J.-L. Nieto was reelected as chairman for the triennium 1985-1988.

In addition, a meeting of interest to WG members 'Structure and Dynamics of Elliptical Galaxies' to be held in Princeton in May 1986 (IAU Symposium, 127) was presented as well as the content of another WG group meeting entitled 'Structures and Substructures in Galaxies' that will be proposed as IAU Colloquium possibly in Japan at the turn of 1988.

At Dr. de Vaucouleurs' request, recent publications from the University of Texas Monographs in Astronomy were also presented to the audience.

Six communications were given:

P. van der Kruit (Netherlands): The central surface brightness of spiral disks.

K. Kodaira, M. Watanabe, S. Okamura (Japan): Bulge-disk models based on digital photometry.

V. Afanasjev, M. Capaccioli, H. Lorenz (Italy): NGC 1023/1023a: an interacting system?.

J. Gallagher, D.A. Hunter, M. Peck, H. Bushouse (USA): Spectral analysis of blue galaxies.

F. Bertola, G. Galletta, W.W. Zeilinger (Italy/Austria): Photometry of dust-lane ellipticals.

J.-L. Nieto, F. Machetto, M. Perryman, S. di Serego Alighieri, G. Lelievre (France, USA): UV observations of the nucleus of M31 with the ESA Photon Counting Detector.

Van der Kruit:

In collaboration with M. de Vries all background disk galaxies on the J-plates of the Palomar-Westerbork survey with an estimated angular size of >2 arcmin were digitized for surface photometry. All 51 systems were in the UGC catalogue and the diameter given in the UGC are at about $\mu_B \sim 26.5$ mag arcsec⁻². The face-on extrapolated central surface brightness μ_B of all systems is in the range 21.78 ± 0.70 mag arcsec⁻² (r.m.s.) and evidence is presented that this is not a result of observational selection.

Kodaira:

Systematic properties of spheroid and disk of 167 selected galaxies in the Virgo Cluster and the Ursa Major Clouds are investigated on the basis of composite models profiles consisting of r_1^4 -law spheroid and an exponential-law disk. To each galaxy a model is assigned which shows the smallest r.m.s. of residuals in profile among the ten models nearest to the actual galaxy in the three-dimensional parameter space of diameter, mean surface brightness and mean concentration index. ($\log D_{26}$, SB, $X1(P)$), introduced in the previous papers of the present authors. The main results are: (1) the structural parameters of disks are confined in the narrow ranges (~ 4 mag in brightness-scale parameter and 0.7 dex in \log (length-scale parameter) while those of spheroids occupy very wide ranges (9 mag and 1.9 dex, respectively). (2)

With increasing morphological type index, the spheroid becomes larger and fainter. (3) There is a very tight correlation between the spheroid-to-disk ratio of the length-scale parameter and that of the brightness-scale parameter, indicating an interplay between spheroids and disks at the time of their formation. (4) Elliptical galaxies seem to have a disk, if any, either more compact or looser and larger than those of spiral galaxies. (4) Lenticular galaxies behave as intermediate between spiral and elliptical galaxies.

Kodaira:

Parameters representing the velocity-scales within galaxies are introduced based on the length-scale parameters and the surface-brightness parameters derived from digital surface photometric data in the previous study on the bulge-disk models, under the assumption of the constant mass-to-luminosity ratio. One velocity scale, which corresponds to the rotational velocity in the disk, shows a high correlation to the observed width of the HI 21 cm line and also to the absolute visual magnitude. This correlation can be explained as the results of the empirical laws found for the bulge-disk models in the previous paper, namely the narrow range of the length-scale of the disk, and the tight interplay of the ratios of the length- and the surface-brightness scales between the disk and the bulge.

Lorenz:

Kinematical information on the NGC 1023 system was obtained from medium dispersion spectra taken with the Photon Counting Multichannel Spectrophotometer at the 6 m telescope of the USSR Academy of Sciences. The velocity difference between the galaxy and the cloud is $127 \pm 30 \text{ km s}^{-1}$. On the basis of a detailed HI study by Sancisi et al. (1984) and photometric investigation it was concluded that NGC 1023A is a Magellanic-type galaxy at $M_B = 17.5 \text{ mag}$ which lost 90% if its gas content in a tidal encounter of the system with NGC 1023. The timescale of the evolution of the system is on the order of 10^8 years. The gas surrounding NGC 1023 has probably an external nature and is not driven out by internal sources of the S0 galaxy.

Gallagher:

Stellar populations are potentially important probes of galaxy evolutionary histories. A number of groups have approached this problem by using theoretical models to synthesize spectra which can then be compared with observations. For several years we have been utilizing more empirical mathematical programming methods developed by M. Peck to analyze spectrophotometric measurements of blue galaxies. These models are very effective in reproducing spectra, but provide only limited information on evolutionary histories. We are therefore exploring methods to continue the theoretical and mathematical spectral synthesis methods with other measurements of galaxies in order to improve this situation, e.g. by extending the diagnostic techniques described by Gallagher, Hunter, and Tutukov (1984, Ap. J. 284, 544).

Galletta:

In the frame of a more extended study on the structure of a number of dust lane ellipticals, we present the photometric results concerning 8 of these galaxies. They are: Anon 0151-4S, NGC 1947, NGC 2534, IC 4320, NGC 5266, NGC 5363 and NGC 5485, all showing a dust lane along their apparent minor axis, and Anon 1029-459 in which the dust lane lies on the apparent major axis and is strongly warped outward. The plates come from the 4m AAT of sidring spring and from the 1.22 m Asiago Telescope. The structure of the dust lane is well defined in NGC 5266 as a warped ring of dust with a small HII region in the inner part, while in NGC 1947 it consists of a number of rings which late to the spiral arms. All these objects follow the R_{\dagger} law for their luminosity profile.

Nieto:

The nucleus of M31 was observed at the CFH in a near-UV band (3750 Å, $\Delta\lambda = 30 \text{ Å}$) for 4000 seconds. The FWHM is 0".75. The resulting image shows:

1) numerous dust features, including a thin nuclear dust lane, oriented along the

major axis of the galaxy and cutting the nucleus at no more than 0.3 from the center,

(ii) strong ellipticity and orientation changes as well as an off-centering of the very central nuclear isophotes with respect to the outer ones.

The dust appears to be correlated with the light distribution and with the stellar potential since the dust lies in the equatorial plane of the nucleus.

25 November: Binary, multiple and merging galaxies (two sessions)

CHAIR: F. Bertola

K. Wakamatsu (Japan): Structure of the polar ring galaxy NGC 4650A.

F. Bertola, G. Galletta (Italy): Dynamics of dust lane ellipticals.

W. Sparks, J.V. Wall (UK): Dust in elliptical galaxies.

S. van den Bergh (Canada): Galaxy mergers and globular clusters.

C. Dupraz, F. Combes (France): Shells around elliptical galaxies.

J.-L. Nieto, Ph. Prugniel (France): Tidally truncated elliptical galaxies.

Y. Terzian (USA): HI observations of binary galaxies.

H. Bushouse, J. Gallagher (USA): Star formation in violently interacting spiral galaxies.

J. Mahoney, B. Burke, J.M. van de Hulst (USA/Netherlands): Quantitative study of the interaction in NGC 4038/39.

S.M. Alladin (India): The merger time of binary galaxies.

T.K. Chatterjee (India): Impulsive approximation studies of ring formation.

Wakamatsu:

From the surface photometry of NGC 4650A, we found that the gaseous component is distributed in a ring and the stellar component in a disk, making a polar stellar disk. After forming the inner stellar disk, the gas in the inner region of the polar disk would have fallen into the nuclear region due to shock waves that was caused by interaction of the gas and the deep potential well of the S0 disk. This mechanism is similar to that of galactic shocks in spiral and barred galaxies.

Galletta:

The kinematics of a sample of dust lane ellipticals are studied. The result is that when the dust lane lies along the minor axis, the rotation axis of the gas is perpendicular to that of the stars, indicating an external origin for the gas.

Three out of four warped dust lane ellipticals exhibit prograde motions in the warps, suggesting that the warps are transient phenomena, if stellar counterstreaming is negligible.

While ellipticals with the dust lane perpendicular to the major axis are both fast than slow rotators, those with the dust lane parallel to the major axis are only fast rotators.

In addition, the first of the two above type greatly outnumber those with the dust lane parallel to the major axis, if any of this latter type indeed exist.

Sparks:

To search for discrete dust features, B-(reconstructed I) colour maps were derived from CCD images of 30 nearby elliptical galaxies. Both chaotic and smooth, symmetric dust-lanes were found, the former in radio ellipticals, the latter in radio-quiet ellipticals. Red nuclei are common in active ellipticals. The data indicate that although on occasion radio emission may be triggered by external gas accretion, the dominant mechanisms are regular internal processes.

Van den Bergh:

1. Spirals. Van den Bergh and Morbey have shown that clusters of all ages in the Magellanic Clouds are significantly more flattened than their galactic counterparts. This shows that our own Milky Way system did not form by the merger of ancestral

Magellanic-type irregulars. Furthermore the rarity of carbon stars in the galactic halo indicates that no Magellanic-type irregular has merged with the Milky Way during the last few billion years. An additional argument against the idea that mergers were a major factor in galaxy building is provided by the radial metallicity gradient of galactic globular clusters and the even stronger correlation between cluster diameter and galactocentric distance that is observed in the Galaxy, M31 and the peculiar elliptical NGC 5128. Not unexpectedly the specific globular cluster frequency, i.e. the number of globulars per $M_V = -15$ of galaxy luminosity, depends strongly on Hubble-types and ranges from $S = 3$ in the galaxy NGC 4594 to 0.3 in the Sb galaxy NGC 4565.

2. Ellipticals. Perhaps the strongest argument against the notion that most ellipticals form from merging spirals is provided by the fact that elliptical galaxies typically have specific globular cluster frequencies $S \sim 3$ in the field and $S \sim 6$ in Virgo. These values are an order of magnitude higher than those which are observed in spirals of type Sb. This discrepancy is reduced by only a factor of 2 by taking into account the fact that spiral galaxies will fade in brightness as star formation dies out following the removal of gas during mergers. It is therefore concluded that field ellipticals contain ~ 5 times and Virgo ellipticals ~ 10 times as many globular clusters as would be expected if they had been formed by merger of typical spirals.

Combes:

With test particle simulations, we show that shells can help to discriminate between oblate and prolate galaxies. Shells form much more easily during a merger with a prolate elliptical. Dwarf elliptical companions produce shells as well as spiral companions. In numerous shells galaxies, the shell system provides evidence for an extended mass component around the elliptical.

Nieto:

We have approached the problem of the evolution of tidally truncated elliptical galaxies from both observational (Photometry with FWHM 0".5-0".7 and spectroscopy with the CFH Telescope) and theoretical points of view. We have found a fourth tidally truncated elliptical: NGC 4478 and a fourth characteristics common to the four cases: the isophotes are more circular outwards than inwards. This can be explained by the orbital time of the compact about the nearby massive companion being much larger than the dynamical time of its external parts. A simple model for decay with a variable mass for the compact shows that the decay time is much larger than the Hubble time: we conclude that either dynamical friction formulae do not apply or compactness is intrinsic to the formation of this type of ellipticals or there must have been a strongly inelastic encounter after which the decay has occurred as described by our model (e.g. slowly).

Terzian:

Observations of HI in binary galaxies, and in small groups, performed with the Arecibo 100-ft radio telescope were described (Schneider, Helou, Salpeter and Terzian 1985). M/L ratios were derived both from the HI rotation curves, and from pair dynamics, and these are of order 5 to 20, with a maximum dynamical M/L \sim 80.

Gallagher:

A morphologically selected sample of 100 violently interacting spiral systems has been chosen from the UGC on the basis of the presence of tidal tails or other pronounced structural disturbances. Optical spectrophotometry reveals a wide range in stellar content and emission line strengths. On average, the interacting systems have significantly enhanced levels of star deformation as compared with field spirals, but are deficient in detectable active nuclei (Seyferts, Liners). Many galaxies have only old stellar populations in their nuclei, indicating that nuclear star formation or activity are not necessary consequences of interactions. Spatially extended star formation is also common in these systems, and young stars may play an important role in the visibility of tidal tails and other large scale features. A goal of this project will be to combine these data as a means to estimate the level of evolutionary change produced by strong interactions.

Burke:

A study of the hydrogen distribution and dynamics in the interacting system NGC 4038/39 has been made, using the VLA of the National Radio Astronomy Observatory. A simple Toomre-type calculation indicates that the galaxies are interacting for the first time. The best fit to the combined radio and optical data is given by introducing a small amount of dynamical friction (in our admittedly simplified model), but no massive, extended halo seems to be needed. On the contrary, any halo must contain a relatively small fraction of the total mass if it is greatly extended beyond the luminous matter.

Alladin:

The merger times of binary galaxies obtained from the analytic formulae derived under the impulsive and adiabatic approximations are compared with the numerical results by Borne (1984 Ap. J.). The agreement with the numerical results is found to be quite good with the impulsive approximation formulae.

Chatterjee:

A study of the formation of ring galaxies, in the light of disk-sphere collisions, (under the impulsive approximation), indicate that the formation and properties of the rings are closely related to the fractional change in binding energy of the disk galaxy. A relationship exists between the size of the ring and the collision parameters, which enables us to interpret some prominent ring galaxies.