The Cosmic Microwave Background

Dick Bond
CITA, Canada

ABSTRACT

Reionization of the Universe and Its Feedback Effect on Galaxy Formation

Paul Shapiro
University of Texas, USA

ABSTRACT

The first sources of ionizing radiation which turned on in the postrecombination universe exerted a strong feedback on the subsequent formation and evolution of galaxies. Included in these effects was the reionization of the intergalactic medium by the propagation of overlapping ionization fronts, which photoevaporated some protogalactic clouds and altered the thermal history of the gas inside others. The role of hydrogen molecules in cooling primordial gas inside protogalaxies and thereby initiating gravitational instability and primordial star formation was also affected by this radiation, both negatively as a result of photodissociation fronts and positively as a result of the enhanced ionization level and its contribution to molecule formation. We will discuss new results in the study of these gas dynamical processes.

Constraining reionization using the thermal history of the baryons

J. Schaye, T. Theuns, G. Efstathiou, M. Rauch, and W. Sargent
Institute of Astronomy, Cambridge

ABSTRACT

The thermal evolution of the intergalactic medium (IGM) depends on the reionization history of the universe. Numerical simulations indicate that the low density IGM, which is responsible for the low column density Lyman-alpha forest, follows a well defined temperature-density relation. This results in a cutoff in the distribution of line widths (b-parameters) as a function of column density (N). We use hydrodynamic simulations to determine the relation between the cutoff and the effective equation of state of the gas and apply this relation to Keck spectra spanning a redshift range z=2 to z=4.5. We find that the temperature peaks at $z \sim 3$ and interpret this as evidence for reheating due to the second reionization of helium.

Simulating the Structure of Galaxy Formation

Greg Bryan
MIT, USA

ABSTRACT

We use numerical simulations to examine the structure of galaxy formation in a low-omega, cosmological constant-dominated cosmology. The simulations use an adaptive mesh refinement code to provide the dual benefits of adaptive high-resolution as well as eulerian hydrodynamics. We first examine the results of including dark matter, gas and radiative cooling, focusing on the spatial distribution of the collapsed clumps as well as their angular momentum. The effects of gas-stripping are high-lighted. We then show the effect of adding "dirty" physics, including a parameterized form of star formation and feedback.

The role of Tidal Fields and Anisotropic Collapse in Structure Formation

R. van de Weygaert and W. Schaap
Kapteyn Institute, University of Groningen

ABSTRACT

We present recent work on the anisotropic collapse of massive clumps in scenarios of gravitational instability. Based on the analysis of constrained N-body simulations concerning the evolution of galaxy-group sized clumps we have performed a detailed dynamical analysis of the velocity and force fields involved. We focus in particular into the evolution of the infall patterns into clumps, and the extent to which this is influenced by the external tidal fields induced by the larger scale anisotropic filaments and walls in which the clumps are embedded. As the shape and direction of the clump are determined to a considerable extent by the clumps falling in, and the infall direction by the latter is determined by the large scale environment, we expect observationally to see an environment dependent alignment of virialized objects.

Three dimensional radiative transfer for studying the reionization of the universe

Tom Abel
CfA

ABSTRACT

In this oral contribution I will outline how 3D radiative transfer can be included in cosmological hydrodynamical calculations. As first applications I present result from simulations that follow the photo-ionization fronts (hydrogen reionization) driven by stellar sources at high redshift.

Measuring Galaxy Biasing Function From PSCz Survey

E. Branchini[1], Y. Sigad[2], and A. Dekel[2]

[1] Kapteyn Institute - University of Groningen

[2] Racah Institute of Physics, The Hebrew University

ABSTRACT

We present a simple method for measuring the mean biasing function of galaxy from a redshift survey and its application to the recently completed IRAS PSCz catalog. If the biasing relation were deterministic and monotonic, then it can be derived from the Cumulative Distribution Functions (CDF) of galaxies and mass. The former can be measured from redshift survey. The latter turned out to be well approximated by a cumulative log-normal distribution of $1+\delta$ with a single parameter σ_m, the mass variance on a given scale. We show that the biasing relation can be obtained from the CDF of IRAS PSCz galaxies and that the expected uncertainties are small enough to make the method effective. Preliminary results show that the bias of IRAS galaxies is only mildly nonlinear and well described by semianalitic recipes for galaxy formation.

Large Scale Structure in the weakly non-linear regime

Enrique Gaztanaga

IEEC/CSIC

ABSTRACT

Is gravititational instability responsible for the observed large scale structure in the universe? Are galaxies fair traces of the mass? Do we need non-gaussian initial conditions or exotic non-gravitational physics to explain the large voids and other features seem in galaxy surveys? I will give a brief introduction to non-linear perturbation therory as a tool to understand structure formation, in particular through the study of higher order statistics, like the skewness and the 3-point function. I will review how this theory can (and has) been compared with Nbody simulations and the large scale structure observations (mostly as traced by galaxy catalogues, but also by the Lyman alpha forest and weak gravitational lensing). I will present some new results on the 2 and 3-point function measured in the APM Galaxy Survey.

Acceleration of Cosmic Rays at Large Scale Shocks and their Cosmological Implications for Structure Formation in the Universe

F. Miniati[1], D. Ryu[2], T.W. Jones[1], and H. Kang[3]

[1] University of Minnesota, USA

[2] Chungnam National University, Korea

[3] Pusan National University, Korea

ABSTRACT

In this contribution we investigate in detail the properties of cosmic shock waves in simulations of structure formation in the universe. After an introductory description of the extremely complex structure of such shock waves, recently revealed through accurate analysis of numerical data, we concentrate on their role as site for efficient cosmic ray acceleration. Relativistic CR electrons have been observed in GCs through their synchrotron emission and a quantitative assesment suggests the need for recent acceleration mechanisms in there. Moreover, recently the EUVE satellite has revealed that many clusters possess an excess of extreme ultra-violet (EUV) radiation compared to what is expected from the hot, thermal X-ray emitting intra-cluster medium (ICM). Further evidence for nonthermal activity in the ICM comes from detection of radiation in excess to thermal emission in the hard X-ray band above $\sim$ 10 KeV. The detection of CR electrons indirectly proofs the existence of a proton component as well. Estimates of the latter suggest that they could provide a substantial fraction of the total pressure in GCs, thus being of great relevance in a cosmological context. Here, for the first time, we show results about the spatial and spectral properties of CR electrons and protons through numerical simulations which include explicitly both the magnetic field, acceleration of particles and losses in a cosmological simulation. This work is supported in part by the NSF and the University of Minnesota Supercomputing Institute.

Simulations of galaxy formation in CDM models

Neal Katz
University of Massachusetts

ABSTRACT

I will present the results of a series of gas dynamical simulations of galaxy formation in several different Cold Dark matter models. I will discuss galaxy masses, galaxy clustering, star formation rates and absorption properties.

High z evolution of optically and IR–selected galaxies: a comparison with CDM scenarios

A. Fontana, E. Giallongo, N.Menci, S.Cristiani, and S. D'Odorico
Rome Observatory / ESO

ABSTRACT

We summarize in this contribution the results that deep field imaging surveys may provide to constrain galaxy evolution. A combination of ground–based (NTT and VLT) and HST (HDF–N and HDF–S) public imaging surveys have been used to collect a sample of 1712 I–selected and 319 $K \leq 21$ galaxies observed with an extended spectral coverage from the U to the K band. Photometric redshifts have been obtained for all these galaxies, using a spectral library computed from Bruzual and Charlot models. The results have been compared with the prediction of our analytic rendition of the current CDM hierarchical models for galaxy formation that explicitly accounts for magnitude limits and dust extinction. We focus in particular on three observed quantities:

- The galaxy redshift distribution at $K \leq 21$, that has been proposed by Kauffmann and Charlot (1998) as a very robust prediction of any CDM hierarchical model. The derived photometric redshift distribution is in agreement with the hierarchical CDM prediction, with a fraction of only 5% of galaxies detected at $z \geq 2$. This result strongly supports hierarchical scenarios where present–day massive galaxies are the result of merging processes.

- The UV luminosity density ϕ_{2700} is confined within a factor of 4 from $z = 0$ to $z = 4.5$, and is relatively constant from $z = 1$ to $z = 4.5$, although significant field–to–field variations exist and dominate over statistical uncertainties. CDM models in a critical ($\Omega = 1$,$\Lambda = 0$) Universe are not able to produce the density of UV photons that is observed at $z \geq 3$. CDM models in Λ–dominated universe are in better agreement at $3 \leq z \leq 4.5$, but predict a pronounced peak at $z \simeq 1.5$ and a drop by a factor 8 from $z = 1.5$ to $z = 4$ that is not observed in the data. We conclude that improvements are required in the treatment of the physical processes directly related to the SFR, e.g. the starbust activity in merger processes and/or different feedback to the star formation activity.
- The intrinsic sizes of the galaxies are shown as a function of their redshifts and absolute magnitudes. While the brighter galaxies with morphological parameters typical of the normal spirals show a flat distribution in the range $r_d = 1 - 6$ kpc, the fainter population at $0.4 < z < 0.8$ dominates at small sizes. A CDM model that provides the best fit to the local luminosity function and the Tully-Fisher relation is able to reproduce at intermediate redshifts a size distribution in general agreement with the observations, although it tends to underestimate the number of galaxies fainter than $M_B \sim -19$ with disc sizes $r_d \sim 1 - 2$ kpc.

Dark matter halos and disk galaxy evolution

V. Avila-Reese[1], C. Firmani[1,2], A. Klypin[3], and A.V. Kravtsov[3]

[1] Instituto de Astronomia, UNAM

[2] Osservatorio Astronomico de Brera

[3] Astronomy Department, NMSU

ABSTRACT

We study the density profiles of dark matter halos calculated with a generalized secondary infall model and observed in a N-body cosmological simulation for a low-density flat CDM model. We find that the halos have a diversity of density profiles, the most common one being close to that suggested by Navarro, White, & Frenk. This diversity is mainly related to the statistical nature of the halo hierarchical mass aggregation histories (MAHs). We also find a strong correlation of the profiles with the environment. Halos in clusters are more concentrated and with steeper profiles than the isolated halos, while halos in groups are less concentrated and with flatter profiles than the isolated ones. Approximately 70% of the halos are isolated objects. Using a seminumerical method, we study the formation and evolution of disks within the growing halos. We assume spherical symmetry, gentle gas infall with a rate given by the MAH, angular momentum conservation, and stationary star formation within the disk. Several properties of disk galaxies are predicted. Our models allow us to explain the Tully-Fisher relation, its scatter, and the fact that low and high surface brightness galaxies follow the same TF relation. We point out some possible shortcomings of the hierarchical galaxy formation scenario.

Compact HVCs: Galactic Building Blocks in the Current Epoch

R. Braun and B. Burton
NFRA, Leiden Obs

ABSTRACT

We have uncovered evidence for a population of low mass gaseous sub-dwarf objects in the Local Group potential; the compact, high-velocity clouds (CHVCs) (Braun & Burton 1999, A&A 341, 437). Our sample of compact and isolated objects which have been mutiply-confirmed comprises 66 members north of declination -30. While there may be a small degree of clustering, the sample is distributed rather uniformly across the sky. There are likely to be several hundred objects of this class down to current detection limits. This is a dynamically cold system of objects, with a velocity dispersion of less than 70 km/s which is infalling into the Local Group barycenter at about 100 km/s. These properties suggest that these may be quite pristine gas concentrations which have, as yet, had very little interaction with the more massive galaxies, as also suggested by Blitz et al. (1999, ApJ 514, 818). Our recent high resolution imaging has allowed the first distance estimates to be made of several of these systems, placing them in the range 0.5 to 1 Mpc. Similar populations surrounding isolated galaxies and Groups would account for a large fraction of the Lyman limit absorption systems seen toward distant QSOs. We also find evidence for a rather high dark-to-visible mass ratio in these objects, of greater than about 30. A single metallicity determination has been obtained, yielding a value in the range 0.040 to 0.070 of solar.

The morphological evolution of galaxy satellites

F. Governato[1], L. Mayer[2], M. Colpi[2], B. Moore[3], and C.M.Baugh[3]
[1] Osservatorio Astronomico di Brera
[2] Universita' di Milano
[3] University of Durham

ABSTRACT

We propose an evolutionary scenario for the dwarf galaxies in our Local Group, faint dSphs being the descendents of LSBs and brighter dSphs/dEs being the final state of HSB satellites. We study the evolution of galaxy satellites with high resolution N-body simulations. Satellites, described with up to 3 millions particles each) are modeled as replicas of typical

low and high surface brightness galaxies (LSBs and HSBs). Encounters on high eccentricity orbits (as typical in hierarchical models of galaxy formation) strip LSBs of most of their stars and tend to decrease their surface brightness. On the contrary, bar instability in HSBs leads to substantial loss of angular momentum of the stellar component and to an increase of central surface brightness. In both cases the remnant resembles a spheroidal galaxy with an exponential surface brightness profile. A simple modeling of color evolution and interactions driven star formation gives M/L ratios for the remnants that are roughly consistent with observations.

Dust and metal production in the early universe

Andrea Ferrara
Osservatorio Astrofisico Arcetri

ABSTRACT

I will review the observational and theoretical evidences for the presence of metals and dust in the intergalactic medium from the epoch of reionization to the present. I will discuss the links between these quantities and the reionization history of the universe aimed at determining the nature and evolution of the ionization and pollution sources.

Dust and metals in Damped Lyman-alpha systems

S. Savaglio[1,2], M. Stiavelli[1], and N. Panagia[1,3]
[1] Space Telescope Science Institute
[2] ESA Fellow
[3] On assignment from Space Science Department of ESA

ABSTRACT

We have collected data on all Damped Lyman–α systems (DLA) available in the literature to study the formation and evolution of galaxies in the early Universe. The sample contains 142 DLAs in the redshift range $0.0 < z_{DLA} < 4.4$, 85 of which have some information on the content of heavy elements. There are additional 38 candidate DLAs for which the HI column densities were not measured but some metal column densities were determined. We focused our attention to the properties of dust in DLAs and in particular to the depletion patterns shown by the systems. Comparing with the depletion patterns known for our galaxy and varying the dust–to–metal ratio, we find that for DLAs with more than one measured heavy element (46 DLAs), 78%, 9% and 13% have depletion patterns best represented by that of the warm halo, warm halo+disk, and warm disk, respectively. Applying dust depletion corrections for each DLA, either individually or statistically, we find that the metallicity in 78 DLAs shows a clear evolution with redshift, going from 1/4 of solar at $< z_{DLA} >\simeq 0.5$ to 1/65 of solar at $< z_{DLA} >\simeq 4.2$. This evolutionary trend is intermediate between the one derived from the star formation rate of Lyman–break galaxies, and the metallicity evolution of the IGM obtained with cosmological numerical simulations. We have also considered the problem of obscuration of background QSOs by DLAs galaxies and estimated the extinction for each QSOs for a variety of extinction laws. We find evidence for a systematic dimming of observed QSOs as a function of the expected dust column density. Also we show that this effect can cause an observational bias which makesthe detection of metal rich DLAs harder. Finally we discuss how the DLA galaxies can represent the whole population of galaxies in the evolving Universe.

Magnetic Feedback: The Evolution of Magnetic Fields

Alex Lazarian
CITA and Univ. of Wisconsin

ABSTRACT

I shall discuss how magnetic reconnection influences the growth of the regular and random magnetic field, discuss problem of the current dynamo models and possible solutions.

Feedback Processes, Star Formation, and Galactic Evolution

S. Shore[1] and J. Franco[2]
[1] Dept. of Physics and Astronomy, Indiana University South Bend, USA
[2] Instituto di Astronomia, UNAM, Mexico

ABSTRACT

We review radiative and mechanical processes that govern local star formation within molecular clouds. Photodissociation and photoionization of the cloud, resulting mainly in removal of coolants, are major factors determining the carrying capacity of clouds for massive stars. Mechanically assisted destruction of clouds, mediated by massive stellar winds, also inject turbulence into the interstellar medium and strongly influence the outcome of star formation. Finally, we discuss generic global models for how star formation, on the galactic scale, can be understood within deterministic and stochastic frameworks.

The FUV Radiation Field and the Two Phase Structure of the Interstellar Medium

A. Parravano[1,2], D.J. Hollenbach[2,3], and C.F. McKee[3]

[1] Universidad de Los Andes, Venezuela

[2] NASA Ames Research Center

[3] University of California,Berkeley

ABSTRACT

Far Ultraviolet Radiation (FUV, $6ev < h\nu < 13.6ev$) has been recognized as the main source of heating of the neutral interstellar gas. Given the pressure of the interstellar medium (ISM) the FUV field determines whether the thermal balance of the neutral gas results in cold ($T \sim 50 - 100K$) clouds (CNM), warm ($T \sim 10^4 K$) (WNM), or a combination of the two (the two phase ISM). The sources of FUV radiation are the short-lived massive stars that form generally in associations in the galactic disk. The interstellar FUV field at a given point in the interstellar medium rises or falls as nearby associations form and die. The state of the interstellar gas depends then largely on the the distribution of stellar masses in associations and on the birth-rate and size distribution of these associations. Since the FUV luminosity of an association is an increasing function of its size, but the birth-rate of associations decreases with size, the FUV field is expected to present fluctuations with a variety of amplitudes, the larger ones being less frequent. We present results for the time hystory of the FUV field for points in the local ISM of the Milky Way Galaxy. The presence of this fluctuating heating rate converts CNM to WNM and vice versa. We show how to calculate the average fractions of the gas in the CNM and WNM when the interstellar gas is subject to this fluctuating FUV field. Specific results are shown for the local ISM. The knowledge of how these fractions depend on the gas properties (i.e. mean density and composition) and on the FUV-sources (i.e. the star formation rate, or the IMF, or the size distribution of associations) is a basic step in building any detailed model of the large scale behavior of the ISM and the mutual relation between the ISM and the SFR.

Starbursts and the Mixing of Heavy Elements with the ISM of Different Hubble Type Galaxies

Guillermo Tenorio Tagle
INAOE

ABSTRACT

Here I show the two clear different paths followed by the ejecta of correlated type II SN as a result of the size of the starburst and the density and mass of their parent galaxy. In the case of the nuclei of massive ellipticals and bulges of spirals, as well as for nuclear starbursts in spiral galaxies, it is quite clear that most of the metals produced by the massive bursts of star formation are dumped onto the intergalactic medium. This happens once the resultant superbubble reaches the outskirts of a galaxy, causing a super or galactic wind. The product of less massive starbursts is however retained by galaxies, even in the case of blue compact dwarfs, leading after several times 10^8 yr to an enhanced abundance of their ISM. I will show that immediate mixing only occurs within the large superbubble interiors, causing them to radiate following a scaled up cooling law, while boosting their emissivity in X-rays.

Gaseous and stellar kinematics in gas-rich early-type galaxies

N. Caon[1], M. Pastoriza[2], and D. Macchett[3]
[1] IAC, Tenerife, Spain
[2] UFRGS, Porto Alegre, Brazil
[3] STScI, Baltimore, USA

ABSTRACT

We have analyzed gaseous and stellar kinematics in 14 gas-rich early-type galaxies. The majority of the sample exhibit irregular gaseous velocity profiles; gas/star counter-rotation is visible in 5 galaxies. We also find 5 counter-rotating nuclear stellar cores, and 5 more galaxies with inner components kinematically decoupled from the main stellar body. We interpret these results as an indication that the ionized gas has an external origin, is generally not in equilibrium, and may have been acquired recently. The merging and accretion events that brought the gas into the galaxy have also likely left their signature on the stellar kinematics.

Velocity Modification of HI Power Spectrum

A. Lazarian and D. Pogosyan
Canadian Institute for Theoretical Astrophysics

ABSTRACT

The distribution of atomic hydrogen in the galactic plane is usually mapped using the Doppler shift of 21 cm emission line and this causes the modification of the observed spectrum. We calculate HI spectrum in the velocity space and derive the observed spectrum dependance on the statistics of velocity and density fields. We show that the inversion procedure suggested in Lazarian (1995) provides 3D spectrum of HI emissivity and the shallow spectrum reported there may be the consequence of the underlying Kolmogorov-type *velocity* turbulence. The alrernative expalantion that the actual HI density spectrum is shallow cannot be completely ruled out on the basis of the observational data available but seems less likely. Indeed, we calculate how the spectra vary with the change of velocity slicing and show that the available data is supportive of the *velocity domination* of the observed 21 cm intensity spectrum. We claim that allows the interpretation in terms of the Goldreich-Shridhar spectrum of MHD turbulence. We generalize our treatment for the case of a statistical study of turbulence inside individual clouds.

A low metallicity gas shell around radio galaxy 0943–242 at z=2.92

L. Binette[1] and J. Kurk[2]
[1] IA-UNAM, Mexico
[2] Leiden, Holland

ABSTRACT

The radio galaxy 0943–242 presents absorption troughs superposed not only to the Lyman alpha emission line but also to the emission CIV doublet line. We prove that the (large scale extended) emission and absorption gas cannot be co-spatial and share the same origin because the metallicity of the absorption and emission gas phases are very different. We propose that the absorption gas lies in a huge gas shell $D \gg 30$kpc external to the galaxy and which is only slightly enriched as compared to primordial abundances.

Initial angular momentum distribution in forming galaxies and correlations between present day structural parameters

Xavier Hernandez
Osservatorio Astrofisico di Arcetri

ABSTRACT

Starting from an initial dark halo structure within which the baryonic material of a galaxy is contained, a simple galactic formation scenario is followed. The baryons contract to form a disk in centrifugal equilibrium, changing the global gravitational potential to which the dark halo reacts adiabatically. A tidal interaction scheme is used to calculate the initial radial distribution of the specific angular momentum for the baryons, which in turn determines the centrifugal equilibrium radial density profile of the disk. The density profile of the dark matter is chosen so that the resulting galactic rotation curve is compatible with observations of both high surface brightness late type galaxies and low surface brightness galaxies, depending on the value of the initial angular momentum. A Toomre criterion is used to estimate the velocity dispersion inside the galactic disk, which is compared to the rotation velocity to kinematically define a bulge region. A relation between the bulge to disk ratio and the disk scale length is found, together with a natural explanation for the observed correlations between bulge and disk parameters of late type galaxies. The results are compared to light profile decomposition studies found in the literature.

Dusty flows, grain alignment and polarization

Pepe Franco[1]
[1] Instituto de Astronomia, UNAM, Mexico

ABSTRACT

Chemodynamical Evolution

Roberto Terlevich
Institute of Astronomy, UK

ABSTRACT

I will present results from computations that combine multi-zone chemical evolution with 1-D hydrodynamics. These models are designed to follow in detail the evolution and radial behaviour of gas and stars during the formation of massive spheroids, i.e. massive spiral bulges and ellipticals. The knowledge of the radial gas flows in the galaxy allows to trace metallicity gradients, and, the formation of the high-metallicity core in massive spheroids. The high-metallicity core is formed soon enough and may explain the high metal abundances inferred in high-redshift quasars. The star formation rate and the subsequent feedback regulate the episodes of wind, outflow, and cooling flow, thus affecting the recycling of the gas and the chemical enrichment of the intergalactic medium. The evolution of these sheroids shows several stages, some of which are characterized by a complex flow pattern, with inflow in some regions and outflow in other regions. All models, however, exhibit during their late evolution a galactic wind at the outer boundary and, during their early evolution, an inflow towards the core. The time development of the inner mass inflow could explain the bolometric luminosity of a quasar lodged at the galaxy centre as well as the evolution of the optical luminosity of quasars..

Chemodynamical Evolution of Dwarf Irregular Galaxies and the Effect of Gas Infall

G. Hensler, J. Koeppen, and A. Rieschick
Institut f. Theor. Physik und Astrophysik

ABSTRACT

While the metallicity depletion in dwarf galaxies (DGs) can be explained in general by supernova-driven galactic winds, the reason for their low N/O ratios at low O abundance is not yet completely understood. Chemical evolutionary models that take the usual abundance production of a full stellar population into account can reach the abundance peculiarities but requiring both processes, a stepwise element release and a multiple starburst scenario that account for a selective element reduction by means of galactic winds, respectively. In

contrast, chemodynamical models demonstrate that in DGs evaporation of interstellar clouds surrounded by hot supernova gas leads to an almost large-scale homogenization of interstellar abundance ratios, and, furthermore, non-bursting dwarf galaxies (and outermost HII regions of spiral galaxies) show the same abundance patterns as starburst DGs.Since actual radio observations have detected huge HI gas reservoirs enveloping DGs, we have studied to what extent extreme infall of intergalactic and almost pristine gas can provide an alternative and plausible explanation for the chemical signatures. As the main issue we can demonstrate that even when normal element abundances are already reached, such gas infall leads to evolutionary loops in the N/O-O-diagram and can represent the observed range of abundances.

Dynamical and Chemical Evolution of the LMC

H. Dottori[1], E. Bica[1],J.F. Santos Jr[2],J.J. Claria[3], A. Piatti[3], I. Rodrigues[1], M. R. de Oliveira[1], C. Dutra[1], and D. Geisler[4]

[1] I. de Fisica, UFRGS, Brazil

[2] I. de Fisica, UFMG, Brazil

[3] O. Astronomico de Cordoba, UNC, Argentina

[4] Universidad de Concepcion, Chile

ABSTRACT

We analize three different aspects of the LMC dynamical evolution; (i)-the interaction with the Milky Way, which produces the Magellanic Stream; (ii)-that with the SMC, which lead to the bridge between the Clouds, and probably to the formation of the LMC bar and external ring; and (iii)-the int eraction among different LMC subsytems, which mainly determines that the process of star formation responds to a global pattern in the LMC. Finally, the analysis of LMC cluster and field CMDs sets a limit between 11 and 13 kpc to the extension of the LMC disk, probably due to the tidal disrup tion produced by the Milky Way. The LMC chemical evolution obtained from the photometric observation of star clu sters and surrounding fields is strongly linked to the process of star formation. The intermediate age clusters span metallicities [Fe/H] $\approx$ -0.4 to -1.2. ESO 121-sc03, the only known star cluster with age $\approx 9\,$Gyr, has a metallicity comparable to those of the less metallic intermediate age clusters. Finally, the oldest clusters (a handfull known presently) present metallicities [Fe/H] in the range -1.5, -2.2. Surrounding fields present metallicities compatible to those of the neighboring clusters. The fields near the center of the LMC disk, present a rich er process of star formation than the peripheric ones.

Chemical and Dynamical Evolution in Gas Rich Dwarf Galaxies

S. Recchi, F. Matteucci, and A. D'Ercole
SISSA, Italia

ABSTRACT

We study the effect of a single, instantaneous starburst in a gas-rich dwarf galaxy on the dynamical and chemical evolution of its interstellar medium. To do that we adopt an improved 2-D hydrocode coupled with detailed chemical yields originating from supernovae of type II, Ia and from intermediate-mass stars. We find that a galaxy resembling I Zw 18 develops a galactic wind as a consequence of the starburst and most of the metal-rich gas is lost through a galactic chimney. Owing to the energetic contribution of SNIa, ignored in other similar works, the bubble created by the starburst continues expanding during the whole simulation. The various metals are lost differentially and the metals produced by SNIa leave the galaxy more efficiently than others. As a consequence of this we predict larger [α/Fe] ratios for the gas inside the galaxy than for the gas leaving the galaxy. Finally a burst in a primordial gas (without pre-enrichment), after $\sim$ 29 Myr gives chemical abundances and dynamical structures in good agreement with the data of IZw18.

Chemical abundances in star forming regions

Angeles I. Diaz
UAM

ABSTRACT

The uncertainties in the derivation of chemical abundances in the gas ionized by recently formed stars is reviewed. Special attention is given to the so called "empirical calibrations". It is shown that the commonly used oxygen emission lines in the optical are probably not the most suitable ones for these purposes and the potential use of the analogous lines of sulphur in the red part of the spectrum is discussed. Also, the importance of accurate determinations of abundances in the solar/over-solar range is stressed.

Carbon and oxygen Galactic Abundance Gradients Predicted by Chemical Evolution Models

L. Carigi
IA-UNAM

ABSTRACT

Chemical evolution models for the Galactic disk under an inside-out scenario are presented for two sets of stellar yields, both dependent on metallicity. In particular, the effects of massive-star yields on the C/O chemical history of the solar neighborhood and on abundance gradients are discussed. Model predictions are compared with abundance ratios from nearby H II regions, B-stars, dwarf stars, and the Sun. Models with yields by Maeder (1992) can reproduce the observed C/H and C/O abundance ratios and gradients from H II regions, while model results assuming yields by Woosley & Weaver (1995) and Woosley, Langer, & Weaver (1993) are in agreement with C/H values and gradient and C/O abundance ratios observed in B-stars. Models with yields by Maeder (1992) can reproduce the increase of C/O with metallicity in the solar vicinity, while models assuming yields by Woosley & Weaver (1995) and Woosley, Langer, & Weaver (1993) can not. Model results call for: i) yields that account for metal-dependent stellar winds, and ii) a higher metallicity dependence of the wind mass loss rate for massive stars than $Z^{0.5}$, assumed by Maeder (1992). The C/H values derived from Galactic B-stars are about 0.3 dex lower than those from Galactic H II regions and from disk dwarf stars of the solar vicinity, it is suggested that the C abundances derived from B-stars are not representative of the solar vicinity. Predicted O/H, He/H, and surface density distributions are in agreement with observations using both sets of yields. All models predict lower than observed $\Delta Y/\Delta Z$ values, except for M17.

Carbon star luminosity function: a possible test to gauge parent system metallicity

Marc Azzopardi
Observatoire de Marseille

ABSTRACT

Theory predicts that the ratio of the frequencies of carbon stars and M giants of type M6 or later (C/M ratio) depends on metallicity and age. This effet has been confirmed by the low-dispersion spectral surveys by Blanco and associates (Blanco et al. 1978, Blanco & McCarthy 1983) which led them to point out outstanding differences in the C/M ratio when the late-type star populations of the Large and the Small Magellanic Clouds were compared with each other and with that of the bulge of the Galaxy. More recently, very deep transmission-grating searches for very faint carbon stars in some nearby Local Group galaxies, by Azzopardi and associates (see Azzopardi et al. 1999 and papers quoted therein) resulted in the discovery of low-luminosity carbon stars in two slightly metal-poor galaxies, namely the Small Magellanic Cloud and the Fornax dwarf spheroidal, suggesting that the faint end of the carbon star luminosity function might be sensitive to metallicity of the parent system. These preliminary results corroborate the theoretical predictions about the dependance of the mean carbon star luminosity on metallicity leading to the expectation that, for two systems with similar star-formation histories, the mean luminosity of carbon stars would be lower in the more metal-deficient system. As a matter of fact, given two stars of equal mass but different metallicities, the metal-poor one will become a carbon star at a lower luminosity than the metal-rich one since less carbon has to be dredged up to the surface to get C/O>1.

The IMF of starburst systems

J. Melnick and F. Selman
ESO

ABSTRACT

The observational evidence for and against the hypothesis the the slope of the IMF in Starburst is Universal is reviewed. New results on the prototypical starburst cluster 30 Doradus, that reveal a new important systematic bias in the determination of the IMF are presented and used to interpret the observations of other starbursting systems.

The history of star formation in normal late-type galaxies

A. Boselli[1], G. Gavazzi[2], J. Donas[1]

[1] Laboratoire d'Astronomie Spatiale

[2] Universita di Milano, Italy

ABSTRACT

We have collected a large body of UV (2000 Å) and Hα measurements of late-type galaxies. These are used, joint with spectral evolutionary synthesis models, to study the initial mass function (IMF) in the mass range $m > 2$ M$\odot$. Our data are consistent with a Salpeter IMF with an upper mass cutoff M$_{up} \sim 80$ M$\odot$ for galaxies in the morphological type range Sa-Im/BCD. The history of star formation and the amount of total gas (per unit mass) of galaxies are found to depend on their total masses (as traced by the H band luminosity) more than on their morphological type. (or on the "form" of their light distribution as traced by the C_{31} index). The present star formation activity of early-type, massive spirals is up to 100 times smaller than in the past, while in low mass dwarf galaxies it is comparable or higher than that at earlier epochs. Dwarf galaxies have larger gas reservoirs than early-type, massive spirals which exhausted most of their gas in the past. The efficiency in transforming gas into stars and the time scale for gas depletion are not related to the luminosity and/or to the morphological type. The time scale for gas depletion is $\sim$ 10 Gyrs. These and others observational evidences, such as the colour-magnitude relation, are consistent with the idea that galaxies are coeval systems, that they evolved as closed-boxes forming stars following an exponentially declining star formation law with a larger time scale ($\tau \sim$ 10 Gyrs) for low mass, dwarf galaxies (L$_H$ = 10^9 L$_H\odot$), than for massive (L$_H$ = 10^{12} L$_H\odot$), early-type spirals ($\tau \sim 0.5$ Gyrs). The consequences of this interpretation on the evolution of the star formation rate and of the gas density with z per comoving volume of the Universe are discussed.

Star-Formation in the local Universe

M. Treyer[1], M. Sullivan[2], R. Ellis[2], T. Bridge[3]

[1] LAS, Marseille, F

[2] IoA, Cambridge, UK

[3] AAO, Epping, Australia

ABSTRACT

i'll present new spectroscopic observations for a sample of galaxies selected at 2000 A. Nebular emission line measurements allow us to address issues of excitation, reddening and metallicity. The UV and Hα luminosity functions strengthen earlier assertions that the local volume-averaged star formation rate (SFR) is higher than indicated from optically selected surveys. Our data combined with recent redshift survey results suggest a more modest evolutionary trend at $z < 1$ than previously reported. We also find that the UV flux indicates a consistently higher mean SFR than that implied by the Hα luminosity for typical constant or declining SFR. Whilst we can explain most of our observations by intense starburst activity, there remains a small population with extreme UV-optical colours which cannot be understood.

Continuous low star formation rate in dwarf galaxies

Francois Legrand

INAOE

ABSTRACT

Various observations of blue compact galaxies, and particularly of IZw 18, the most metal poor galaxy locally known, have revealed very homogeneous abundance distribution throughout these galaxies. These homogeneous abundances cannot result from the material ejected by the stars formed in the current burst and thus have been produced during a previous star formation episode. Metals ejected in the current burst remain most probably hidden in a hot phase and are undetectable using optical spectroscopy. Combining various observational facts, for instance the faint star formation rate observed in low surface brightness galaxies, we propose that a low and continuous star formation rate occurring during quiescent phases between bursts is a non negligeable source of new elements in the interstellar medium. Particularly, using a spectrophotometric + chemical evolution model for galaxies, we demonstrate that if such a continuous star formation rate occurs during a Hubble time, it reproduces alone the observed abundances in IZw 18. This SFR is comparable with the lowest SFR observed in low surface brightness galaxies. Generalized to all galaxies, the low continuous SFR scenario accounts for various facts: the presence of star formation in quiescent dwarfs and LSBG, the metallicity increase with time in the most underabundant DLA systems, and the metal content extrapolations to the outskirt of spiral galaxies. Also the apparent absence of galaxies with a metallicity lower than IZw 18, the apparent absence of HI clouds without optical counterparts, and the homogeneity of abundances in dwarfs galaxies are natural outcomes of the scenario. This implies that, even if starbursts are strong and important events in the life of galaxies, their more subdued but continuous star formation regime cannot be ignored when accounting for their chemical evolution.

The Morphology, Color, and Gas Content of Low Surface Brightness Galaxies

Karen O'Neil

Arecibo Observatory

ABSTRACT

Recent surveys by O'Neil, et al. (1997, 1998, 1999, 2000) have discovered hundreds of low surface brightness galaxies, systems with central surface brightness fainter than 22.0 B mag arcsec^{-2}, in the local universe. Plots of the surface brightness distribution – that is, the space density of galaxies plotted against central surface brightness – show a flat space density distribution from the canonical Freeman value of 21.65 B mag arcsec $^{-2}$ through the current observational limit of 25.0 B mag arcsec^{-2}. As such, it is likely that a significant percentage of the baryon content in the universe is contained in these diffuse systems. The morphology of the galaxies discovered range in color from blue through the first discovery of red LSB galaxies ($B - V > 1.0$), include both dwarf and intrinsically luminous systems, and vary from well defined spiral galaxies through amorphous blobs. The gas-to-luminosity ratio (M_{HI}/L_B) of the O'Neil, et al. sample range from gas poor through possibly the highest M_{HI}/L_B known ($0.6 \le M_{HI}/L_B \le 180\, M_\odot/L_\odot$). One of the more intriguing finds is that the galaxies with the highest M_{HI}/L_B correspond to some of the reddest (optically) galaxies in the survey, raising the question of why star formation has not continued in these systems. Since the average HI column density in these systems is above the threshold for massive star formation, the lack of such may indicate that these galaxies form a sort of "optical core" which trace a much more extended distribution of neutral hydrogen. Alternatively, a model in which LSB galaxies do not form massive ($> 2\, M_\odot$) stars can explain the presence of both blue and red LSB systems. A subset of the detected LSB galaxies have rotational velocities $\ge$ 200 km s^{-1} and total luminosities at least an order of magnitude below L_*. As such they represent extreme departures from the standard Tully-Fisher relation. In fact, the sample does not

appear to have any significant correlation between velocity widths and absolute magnitudes, with only 40% of the galaxies falling within the 1σ LSB Tully-Fisher relation. Unless the percentage of dark matter in these systems is unusually high, this may indicate the galaxies do not lie in the same evolutionary state as galaxies with lower gas content.

Cosmological and Star Formation Constraints Using Infrared-Excess Galaxies

Lexi Moustakas
Nuclear and Astrophysics Laboratory, Oxford, UK

ABSTRACT

The colors of field infrared excess galaxies ("Extremely Red Objects" and "Faint Red Outlier Galaxies") generally arise from highly obscured star-formation (or AGN) activity, or from passively evolved systems with very high formation redshifts. By a systematic study of the numbers, multi-band colors, and morphologies of such galaxies, we show how it is possible to directly probe or infer dramatic star formation epochs at both intermediate and very high redshifts ($z = 1 - 2$ and $z > 5$ respectively), by calculating photometric redshift ranges and explicit dust/age contents. The study is based on FROGs found using HST/WFPC2 optical and deep Keck/NIRC K-band data in the Westphal/Groth Survey Strip (at Berkeley), and on EROs identified in an ongoing wide $BVRizK$ survey (at Oxford) over several square degrees.

Induced Star Formation in Compact Groups

Jack Sulentic
University of alabama, USA

ABSTRACT

It is now widely accepted that interactions are capable of inducing considerably. The phenomenon is well established for binary galaxies even if the physiscal precesses are not completely understood. The most extreme activity is observed in the so-called merging systems. Compact groups of galaxies have been the subject of much recent debate because they show less evidence for star formation enhancement than is observed in pairs. They also show little evidence for considerable dynamical evolution involving frequent galaxy-galaxy collisions and encounters. This paradox is beginning to resolve itself with the aid of considerable new data on these galaxy aggregates. We focus on a multi-wavelength study of Stephan's Quintet in an effort to show that compact groups evolve without strong starburst or merger activity. The new data also point towards possible explanations.

Merger driven galaxies

Felix Mirabel
Saclay/France

ABSTRACT

I will review the observations of the transformation of galaxy morphology during mergers, with particular emphasis on the formation of elliptical galaxy cores, tidal dwarfs, extranuclear starbursts, and symbiotic galaxies. I will also review the general properties of ultraluminous infrared galaxies, with particular emphasis to the new insights obtained by the observations with the Infrared Space Observatory and the infrared spectro-imager on the VLT.

A Bird's Eye View of Ocular Galaxies

E. Brinks[1], D.M. Elmegreen[2], M. Kaufman[3], B.G. Elmegreen[4], C. Struck[5], M. Thomasson[6], and M. Klaric[7]

[1] Departamento de Astronomía, Guanajuato, Mexico
[2] Vassar College Observatory, Poughkeepsie, NY 12601, USA
[3] Ohio State University, Columbus, OH 43210, USA
[4] IBM, T.J. Watson Research Center, Yorktown Heights, NY 10598, USA
[5] Iowa State University, Ames, IA 50010, USA
[6] Onsala Space Observatory, S–43992 Onsala, Sweden
[7] Midlands technical College, Colombia, SC 29202, USA

ABSTRACT

Ocular galaxies are interacting systems undergoing a close but non–merging encounter which, for a short period of time during a usually prograde, in–plane interaction, display a characteristic "eye–shape" morphology. IC 2163/NGC 2207 is the best studied example to date of such a galaxy pair. VLA HI observations of this pair reveal $10^8\,M_\odot$ HI clouds, streaming motions in excess of 100 $\mathrm{km\,s^{-1}}$, enhanced gas turbulence, an intrinsically oval disk, possible dwarf galaxy formation in tidal debris, and a large warp, all indicative of extreme tidal agitation. Our numerical models reproduce these features in detail and suggest that perigalacticon occurred $\sim$ 40 Myr ago. In this contribution we will highlight images recently obtained with WFPC2 onboard the Hubble Space Telescope (HST), concentrating

on the galaxy IC 2163. We will show that the images reveal inner spiral arms (interior to the eye–shaped oval visible in ground–based images), an impressive array of nearly parallel dust filaments extending like fine brush–like strokes on the eastern (anti–companion) side of IC 2163, and the multi–stranded nature of the dust lane in the NGC 2207 arm that crosses in front of IC 2163. Finally, IC 2163/NGC 2207 will be compared to two other systems which we have studied in detail, i.e., NGC 2535/6 and NGC 5394/5. We will argue that these interacting systems form an evolutionary sequence with time, with IC 2163 being the least evolved, and NGC 5394 already at a stage of post–encounter evolution, exhibiting nuclear starburst activity as a direct result of the past interaction.

Star Formation and Galaxian Environment

H.K.C. Yee

University of Toronto

ABSTRACT

This paper will review some of the work on the relationship between star formation history of galaxies and their environment, and also present some new results based on the CNOC1 Cluster Galaxy Redshift Survey and the CNOC2 Field Galaxy Survey. We will compare the star formation histories of galaxies in the field, in close pairs, and clusters. Of particular interest is the differential evolution of galaxies in the field and clusters. Furthermore, we will also examine the galaxy population gradient as a function of cluster-centric radius and its evolution as a function of redshift. Finally, a discussion of some implications on galaxy and cluster formation and evolution based on the dependence of star formation history on evironment will be presented.

Probing The Evolution Of Early-Type Cluster Galaxies Through Chemical Enrichment

I. Ferreras and J. Silk
University of Oxford

ABSTRACT

A simple chemical enrichment model for cluster early-type galaxies is described in which the main mechanisms considered in the evolution are infall of primordial gas, outflows and a possible variation in the star formation efficiency. We find that only outflows can generate a suitable range of metallicities needed in order to explain the color-magnitude relation. The chemical enrichment tracks can be combined with the latest population synthesis models from Bruzual & Charlot (In preparation) to simulate clusters in a wide redshift range, for a set of toy models with different infall rates, star formation efficiencies or star formation scenarios. The color-magnitude relation of local clusters is used as a constraint, fixing the correlation between absolute luminosity and ejected fraction of gas from outflows. It is found that the correlations between color or mass-to-light ratios and absolute luminosity are degenerate with respect to most of the input parameters. However, a significant change between monolithic and hierarchical models is predicted for redshifts $z \gtrsim 1$. The most important observable that differentiates between these alternative formation scenarios is the population of blue early-type galaxies which fall conspicuously blueward of the red envelope. The comparison between predicted and observed mass-to-light ratios yield an approximate linear bias between total and stellar masses: $M_{\rm Tot} \propto M_{\rm St}^{1.15\pm0.08}$ in early-type galaxies. Given that outflows constitute the driving mechanism for the colors observed in cluster early-types, the metallicity of the intracluster medium (ICM) can be linked to outflows: The color-magnitude constraint requires faint $M_V \sim -16$ galaxies to eject 85% of their gas, which means that most of the metals in the ICM may have originated in these dwarf galaxies. No significant evolution is predicted, in agreement with X-ray observations (Mushotzky & Loewenstein 1997). Other mechanisms contributing to the enrichment of the ICM such as ejected material from mergers that formed the largest ellipticals should be translated into a decrease of the intracluster metallicity at $z \gtrsim 1-1.5$. Forthcoming observations from *Chandra* and *XMM* will help elucidate this point.

Galaxy Evolution: the Cluster-Field Connection

David Schade
National Research Council of Canada

ABSTRACT

A comparison of the properties and evolution of field and cluster galaxies shows similarities as well as differences. In both environments star-forming blue galaxies become more common among the galaxy population with increasing redshift. Both environments ontain elliptical galaxy populations whose evolution is roughly consistent with old, passively evolving models. On the other hand, the cores of rich clusters are dominated by elliptical galaxies together with an S0 population which may evolve dramatically since z=0.5. These phenomena will be discussed in the context of the distributions of galaxy type, size, and surface brightness in local and high redshift cluster and field environments.

Stellar populations and the colour magnitude relation in Coma

A.I. Terlevich[1], H. Kuntschner[2], R. G. Bower[2], N. Caldwell[3], R.M. Sharples[3]
[1] University of Birmingham (UK)
[2] University of Durham (UK)
[3] FLWO, Smithsonian Institution (USA)

ABSTRACT

We use the $C_2$4668, Fe4383, $H\gamma_A$ and $H\delta_A$ spectral absorption line indices, together with U- and V-band photometry of 101 galaxies in the Coma cluster, to investigate how mean age and metal abundance correlate with galaxy luminosity. In particular, we use the line index measurements to address the origin of the colour–magnitude relation (CMR). We find that the CMR in Coma is driven primarily by a luminosity–metallicity correlation. We additionally show evidence for a relation between age and luminosity, in the direction predicted by the semi–analytic hierarchical clustering models of Kauffmann & Charlot (1998), but this is only present in the $C_2$4668 index models, and could be an effect of the lack of non solar abundance ratios in the Worthey models used. By comparing deviations from the CMR, with deviations in absorption index from analogous 'index–magnitude' relations, we find that colour deviations bluewards of the mean relation are strongly correlated with the hydrogen Balmer line series absorption. We show that the properties of these blue galaxies are consistent with the presence of a young stellar population in the galaxies, rather than with a reduced metallicity.

Elliptical galaxies and the Enrichment of the ICM

O. Lopez-Cruz
INAOE-Tonantzintla

ABSTRACT

The Toronto Red-Sequence Cluster Survey: First Results

M.D. Gladders and H.K.C. Yee
U. of Toronto

ABSTRACT

The Toronto Red-Sequence Cluster Survey (TRCS) is a new galaxy cluster survey designed to provide a large sample of optically selected $0.1 < z < 1.4$ clusters. The planned survey data is 100 square degrees of two color (R and z') imaging, with a 5σ depth $\approx$2 mag past M* at z=1. The primary scientific drivers of the survey are a derivation of Ω and σ_8 (from $N(M,z)$ for clusters) and a study of cluster-galaxy evolution with a complete sample. In this talk we will give a brief outline of the TRCS survey parameters and sketch the methods by which we intend to pursue the main scientific goals, including an explicit calculation of the expected survey completeness limits. The remainder of the talk will focus on preliminary results from the first set of data ($\approx$ 10 deg^2). These preliminary results provide new examples of rich $z > 1$ clusters, strong cluster lensing, and a possible filament at z$\approx$1.

X-ray Galaxy Clusters and the Cosmic Star Formation Rate

N. Menci and A. Cavaliere
Osservatorio Astronomico di Roma, Dip. Fisica II Universita' di Roma

ABSTRACT

We relate the star formation from baryons condensing in virialized structures to the X-ray properties of the associated diffuse, hot baryonic component. Our computations use the standard "semi-analytic" models to include and connect three sectors of the complex astrophysics involved: first, the formation of dark matter halos through accretion and merging, after the standard hierarchical clustering; second, the star formation governed by radiative cooling and by feedback of the supernova energy into the hot baryonic component; third, and novel, the hydro- and thermodynamics of the hot phase (emitting in X-rays) rendered with our Punctuated Equilibria model. So we relate the X-ray observables concerning the intra-cluster medium (namely, the luminosity - temperature relation, the luminosity functions, the source counts) to the thermal energy of the gas pre-heated and expelled by supernovae following star formation, and then accreted during the subsequent merging events. Our main results are as follows. At fluxes fainter than $F_X \approx 10^{-15}$ erg/cm^2 s the X-ray counts of extended extragalactic sources (as well as the faint end of the luminosity function, their contribution to the soft X-ray background, and the $L_X - T$ correlation at the group scales) increase considerably when the star formation rate is enhanced for $z > 1$ as indicated by growing optical/infrared evidence. Specifically, the counts in the range 0.5-2 keV are increased by factors ~ 4 when the the feedback is decreased and star formation is enhanced as to yield a flat shape of the star formation rate for $2 \lesssim z \lesssim 5$. Such faint fluxes are well within the reach of next generation X-ray observatories like AXAF and XMM. So very faint X-ray counts will soon constitute a new means of gaining information about the stellar processes (particulary, the supernova feedback) at $z > 2$, and a new way to advance the understanding of the galaxy formation. We also discuss the connection between the X-ray properties of clusters and the statistical properties of the galaxy population (luminosity functions, redshift and colour distributions, counts) for different supernovae feedback efficiencies.

Cosmological Constraints from X-ray Cluster Evolution

Mark Voit
STScI

ABSTRACT

The number density of massive clusters evolves much more rapidly in a high-density universe than in a low-density universe, making cluster evolution one of the most sensitive probes of Ω_M. Because the emission-weighted X-ray temperatures of clusters are closely related to cluster masses, surveys of cluster temperatures at various redshifts are particularly useful for constraining the matter density of the universe and also provide valuable information about the shape and Gaussianity of the perturbation spectrum on these scales. The Einstein Extended Medium Sensitivity Survey (EMSS) is a complete sample of clusters that, by virtue of its relatively large solid angle and moderate depth, contains several very massive clusters at z ¿ 0.5. We have now obtained X-ray temperatures for all these massive high-z clusters and have constructed the first temperature function at these redshifts. The comoving number density of massive clusters has grown during the last half a Hubble time, but only modestly. Maximum likelihood fits of the EMSS cluster temperatures to Press-Schechter models of structure formation yield Ω_M of 0.3 ± 0.1 (flat) or 0.4 ± 0.1 (open), with $\Omega_M > 0.8$ ruled out at the 3-σ level.

A model to explain periodic & cuasi-periodic X-ray variability in AGN

D. Dultzin-Hacyan[1], J.A. de Diego[1], and D. Nun ez[2]
[1] Instituto de Astronomía, UNAM
[2] Instituto de Ciencias nucleares, UNAM

ABSTRACT

We present a mechanism to produce X-ray transient periodic variations in AGN. We show how energetic radiation, which is emitted by the inner edge of a thick accretion disk, may break a few (one in $\sim 10^{25}$) proton-electron couplings in the infalling plasma by Compton scattering. Unbound electrons released by this mechanism will acquire enough energy to escape through the inner funnel into the disk corona creating a zone of net negative charge; these electrons will be temporarily prevented from infall by the radiation pressure of the disk.

As for the decoupled protons in the infalling plasma, they will produce a net positive charge in the black hole. We show that the increasing electric repulsion on protons will eventually become strong enough to significantly reduce the accretion rate. This in turn, will reduce the radiation pressure until the decoupled electrons from the corona are electrically attracted into the hole and neutralize its charge. We describe how this process produces a periodically (or quasiperiodically) variable component on the X-ray luminosity. This periodic emission may be observable as an additional component to the underlying X-ray luminosity of some AGN, as long as no other perturbations to the accretion rate arise. We apply our model to different types of AGN where X-ray periodic or quasiperiodic variability has been reported, and we are able to successfully explain the observations.

ISOCAM Deep Surveys

David Elbaz
Univ. California, Santa Cruz

ABSTRACT

Deep 7 and 15 micron survey: Spectrophotometry, Morphology and Spectral Energy Distribution of ISO sources

Hector Flores
CEA, Service d'AStrophysique

ABSTRACT

The CFRS0300 and CFRS1452 fields has been deeply imaged with the Infrared Space Observatory (ISO) using ISOCAM through the LW2 (7-8.5μm) and LW3 (12-18μm) filters. Careful data analysis and comparison to deep optical and radio data have allowed us to generate two catalogs at 7 and 15 μm. I will present the nature of the ISO sources. The spectral energy distributions (SED) for each of the sources have been derived using from radio to UV photometry. By deriving their FIR luminosities by interpolation, we can estimate their Star Formation Rate (SFR) in a way which does not depend sensitively on the extinction. 75% (-40%, +10%) of the star formation up to z$\leq$ 1 is related to IR emission. The SFR derived by FIR fluxes is likely to be $\sim$ 2.9 times higher than those previously estimated from UV fluxes.

Observational constraints on the formation of elliptical galaxies: a NICMOS-optical survey

T. Treu[1,2] and M. Stiavelli[1,2,3]

[1] Space Telescope Science Institute

[2] Scuola Normale Superiore

[3] ESA

ABSTRACT

When did elliptical galaxies form? Were they assembled at $z > 1$, or the old stellar populations seen in local ellipticals were put together only by a later merger? In order to answer to these questions we have started a NICMOS-optical survey (Treu and Stiavelli, 1999, ApJ Letters). By means of a morphology-color selection criterion we identify high redshift elliptical candidates (HizECs; $z > 1$). The density of HizECs measured on the first 13.74 arcmin^2 surveyed is lower than what is predicted by a pure passive evolution model with a high redshift of formation (z> 5), assuming the local luminosity function (LF) and constant comoving density. On the other hand, a substantial number of HizECs is found, possibly indicating that some (10-66 %) of the local E/S0s were already assembled at $z > 1$. The rest of them may have been formed later, may not be identified as red-ellipticals because of interactions, or later episodes of star formation.

Merging in a Hierarchical Universe: Implications for LBGs, AGN, and DLAS

Rachel Somerville

University of Cambridge, UK

ABSTRACT

According to the hierarchial structure-formation scenario, gas-rich mergers were significantly more common in the past. This has a variety of theoretical implications for three different populations of objects that have been identified at high redshift: Lyman-break galaxies, quasars, and Damped Lyman-α systems. I will discuss how these objects fit together within the hierarchical framework, and show specific predictions from semi-analytic models.

Submillimetre and Millimetre Wavelength Surveys and the History of Star Formation at High-Redshift

David H. Hughes
INAOE

ABSTRACT

Using the new submillimetre (submm) array camera SCUBA on the 15-m JCMT it is now possible to conduct unbiassed submm selected surveys and quantify the amount of star-formation activity in the young Universe by observing directly the rest-frame FIR emission from dust in high-redshift galaxies. I will review the results from recent blank-field 850μm surveys that cover a range of complementary depths (0.5mJy $<$ S(850μm) $<$ 10mJy) and areas (0.0015 - 0.2 sq. degrees). This summary will include a discussion of (i) the observed source-counts, (ii) the contribution of the submm sources identified in these surveys to the submm background, (iii) follow-up mm interferometry, (iv) the importance of the observed spectral energy distribution in discriminating between the alternative optical/IR/radio counterparts, (v) the redshift distribution and hence star-formation history of the submm sources. However gaining a more accurate interpretation of these current submm cosmological surveys is prevented by the restricted range of wavelength and flux density over which the submm source-counts are measured, the uncertainties in the redshifts of the submm-selected galaxies and the ambiguities in the identifications of their optical/IR and radio counterparts. This review will also describe the future ground-based millimetre surveys and balloon-borne submm surveys which will alleviate many of the above deficiencies in the existing submm data.

Detailed Characteristics of Starforming Galaxies at $z \sim 3$

J.D. Lowenthal[1], L. Simard[2], and D.C. Koo[2]
[1] UMass
[2] UCO/Lick Obs.

ABSTRACT

We report on an ongoing program to study the detailed characteristics of Lyman Break Galaxies at redshift $z \sim 3$. We focus on mass as an elusive but crucial piece of information needed to understand the role of LBGs in galaxy formation and evolution, and their connection to local galaxies today. Using spatially-resolved spectroscopy from Keck, we derive rough kinematic masses of a small sample of LBGs as faint as $I = 26$ in the Hubble Deep Field. The galaxies show a wide range of derived masses, from less than $10^{10} M_{\odot}$ to over $10^{12} M_{\odot}$. Combined with observed sizes, luminosities, and star formation rates, this implies that selecting galaxies at high redshift by searching for signatures of active star formation (strong UV continuum with a Lyman limit and/or Ly alpha break) reveals populations as disparate as those seen locally under the same selection criteria, i.e., ranging from starbursting dwarf galaxies to massive M* or larger starbursts.

Internal Kinematics of Blue Field Galaxies to z=0.7

Gabriela Mallen-Ornelas

University of Toronto and Universidad Catolica de Chile/Princet on University

ABSTRACT

The internal kinematics of a galaxy are closely related to its mas, and can provide an insight into the nature of a high-redshift galaxy independent of any changes in appearance that may be caused by bursts of star formation. In particular, kinematic studies can be used to constrain how much luminosity evolution an individual galaxy may have undergone. We present the results of a survey of the internal kinematics of typical blue L_* galaxies at z∼0.6. Blue galaxies represent the most strongly evolving population to intermediate redshifts, as seen in the luminosity function from the Canada-France Redshift Survey (CFRS, Lilly et al 1995, ApJ 455, 108). Targets for the present study were selected regardless of size or morphology, and useful kinematic information was obtained for 26 galaxies at $0.1 < z < 0.7$, most of them bluer than a local Scd galaxy. Emission lines were used to measure internal velocity dispersion σ_v, and sizes were measured from HST imaging. We found that galaxies in our sample at $z < 0.5$ have σ_v, sizes, luminosities, and morphologies similar to those of local galaxies. However, blue galaxies at $z > 5$ have sizes and σ_v similar to those of local Irregulars — consistent with their HST morphologies — but they are generally 1–2 mag brighter than local galaxies of similar size and σ_v. These results support the idea that the excess of blue L_* galaxies at $z \sim 0.6$ is caused in great part by a population of brightened small late-type galaxies.

What do High Redshift Galaxy Clusters Look Like?

P. Francis[1], G. Wilson[1], and B. Woodgate[2]
[1] Australian National University
[2] NASA Goddard Space Flight Center

ABSTRACT

It is now clear that galaxies are strongly clustered in the early universe (redshifts above two). Theory suggests, however, that these galaxy "clusters" should be very different from clusters today, or at redshift one. We review the theories and observations, concentrating on the Francis Cluster, an enormous concentration of galaxies at redshift 2.38. We show that this cluster (and maybe all high redshift clusters) contains a core or remarkably old and massive elliptical galaxies, seemingly little different from those seen at redshift one. This core of elliptical galaxies is surrounded by a vast halo of neutral hydrogen, reminiscent of a Zel'dovich pancake. We will also present our new HST imaging of the cluster.

Metals in the Lyman Alpha Forest

Sara Ellison
Institute of Astronomy, Cambridge

ABSTRACT

Once thought to be chemically pristine and unenriched by metals, the Ly alpha forest has now been incontrovertibly shown to contain elements such as C in a large fraction of high column density clouds. The origin of these metals is as yet unclear, the two most likely enrichment scenarios being that of in-situ metal production and Population III star formation. Determining the abundances in low column density Ly alpha clouds may be most instructive in distinguishing between these two scenarios, however in these weak absorbers the CIV lines are extremely difficult to detect. Here, we present very high S/N ($\sim$ 200), high resolution ($\sim$ 6 km/s) spectra of 2 bright, high redshift QSOs with which we probe the inter-galactic medium using two contrasting methods of analysis in order to determine whether metals pervade the IGM at all column densities.

Ly alpha absorbers associated with very nearby galaxies

S. Cote[1], T. Broadhurst[2], C. Carignan[3], K. Freeman[4], R. Wyse[5]

[1] HIA/NRC

[2] ESO

[3] U. de Montreal

[4] MSSSO

[5] JHU

ABSTRACT

Halos of 8 nearby galaxies (within 3000 km/s) were probed at large galactocentric radii using background quasars observed with HST GHRS and STIS. The quasar-galaxy separations range from 40 to 270 kpc. Ly alpha lines are succesfully detected in the spectra of quasars at impact parameter less than 160 kpc from the galaxy. However in many cases the velocities of these Ly alpha lines do not match smoothly with the galaxy inner velocity field. Moreover many more low-redshift Ly alpha lines are detected in the quasar spectra at redshifts unrelated to the target galaxies and which do not appear to be associated with any other galaxy. It thus seems that only a minority of Ly alpha lines arise in extended gaseous disks of galaxies.

Galaxy Collisions and Star Formation

S.A. Lamb and N.C. Hearn

University of Illinois, Center for Theoretical Astrophysics

ABSTRACT

Galaxy collisions may be the predominant cause of star formation in galaxies over the course of their lifetimes. In the local universe, strong collisions between comparable mass galaxies are rare, and star formation in gaseous disks usually takes place relatively quiescently. However, it is thought that there was an epoch in the past when both strong and glancing collisions between comparable mass galaxies were much more common. These interactions would have produced strong tidal torques and density waves, as observed in the rare, strongly interacting disk galaxies of the local universe. Observations of recently impacted disk galaxies usually show evidence of enhanced rates of recent and current star formation (starbursts). Our three-dimensional numerical simulations of collisions between comparable mass galaxies demonstrate that the gas volume density in the disk can be increased by significant factors, both in the nucleus and in pronounced features that form well away from the galactic center. These collision-induced density enhancements can give rise to ring galaxies, strong, one-armed spirals, and grand-design spirals. The very high density regions produced experience strong shocks in many circumstances, which may play an important role in determining the subsequent amount and exact location of star formation. We present comparisons between multi-wavelength observations of star forming, impacted galaxies and our 3-D numerical simulations of galaxy collisions involving disk galaxies. We show that the timescale for massive star formation can be very short, and that the resulting morphology and velocity structure in the disk can be understood for several well-observed impacted disk galaxies. Evidence that the presence of molecular gas is a necessary, but not sufficient, requirement for star formation in colliding galaxies will be presented. (If time and equipment are available, a video displaying some of these results can be shown.)

Models of Spectral Galaxy Evolution including the Effects of Dust

C.S. Moeller[1], U. Fritze v. Alvensleben[1], K.J. Fricke, [1], and D. Calzetti[2]

[1] Universitaets-Sternwarte Goettingen

[2] STScI

ABSTRACT

To analyse the effects of dust to the UV emission in various galaxy types we present our evolutionary synthesis models which includes dust absorption in a chemically consistent way. The time and redshift evolution of the extinction is based on the evolution of the gas content and metallicity. Comparing our model SED's with templates from Kennicutt's and Kinney et al.'s atlas we show the detailed agreement with integrated spectra of galaxies and point out the importance of aperture effects. We are able to predict the UV fluxes for different galaxy types. Combined with a cosmological model we show the differences in the evolutionary and k-corrections comparing models with and without dust.

The masses and evolution of galaxies from z=0 to z=1

Jarle Brinchmann

Institute of Astronomy, Cambridge University Department of Physics, Oxford University

ABSTRACT

A newly developed technique to determine stellar masses of galaxies from photometry, accurate to < 0.2 in $\log M$, is presented and applied to a sample of 364 field galaxies with HST imaging and spectroscopic observations. Using this sample we I) study the evolution of the mass density in the universe, showing that spiral galaxies are converted into E/S0 galaxies and that high redshift peculiar galaxies end up as normal galaxies locally, II) address the question of evolution of spiral galaxies, showing that spiral galaxies of a give mass are smaller at higher redshift and determining their luminosity evolution using the M/L relation at different redshifts. Finally, III) we study the star formation properties of this sample and show that most stars in massive galaxies formed at $z > 1$, confirming and strengthening the "downsizing" scenario of Cowie et al. (1996), and the theoretical implications of these results are discussed.

The dependence of tidally-induced circumnuclear starburst emission on cluster density

C. Moss[1] and M. Whittle[2]

[1] Vatican Observatory Group, Steward Observatory, Univ. of Arizona

[2] Department of Astronomy, Univ. of Virginia

ABSTRACT

A survey of H alpha emission in 320 spiral galaxies in 8 nearby clusters shows an enhancement of circumnuclear starburst emission with increasingly rich clusters. These observations provide convincing evidence that spirals have been transformed into S0s in clusters predominantly by tidal forces, a picture fully in accord with the most recent numerical simulations of clusters. For the richest clusters, the enhancement of starburst emission is greater than would be expected on the basis of increasing galaxy density alone, which may explain the anomalous result for the type - galaxy surface density relation found for low richness clusters at intermediate redshift.

Making Nuclear Starbursts: Clues from a Molecular Gas Survey

S. Jogee[1] and J.D.P. Kenney[2]

[1] Caltech

[2] Yale Univerasity

ABSTRACT

We investigate what causes starbursts in the circumnuclear (inner 1-2 kpc) region of spirals by studying the molecular gas and star formation properties of 11 nearby galaxies, including starbursts comparable to M82 and control non-starbursts. From this study, based on high resolution interferometric CO (J=1->0), optical, and NIR observations, along with radio continuum and HST data, we find the following results. **(i) Gas content:** The star formation efficiency (SFE) or SFR per unit mass of molecular gas is not a simple function of molecular gas content. Both starbursts and non-starbursts can host comparable amounts (2×10^8 to 2.4×10^9 $M_\odot$) of molecular gas, in the circumnuclear region although the SFE can be an order of magnitude higher in the starbursts. **(ii) Large-scale transport mechanisms** All of the galaxies are barred and at least half of the sample starbursts and non-starbursts both show evidence for a recent merger/tidal interaction with minor (1:10) to intermediate (1:4) mass ratio. While bars and moderate external triggers appear to favor circumnuclear activity by chanelling molecular gas into the inner kpc, it is clear that they *are not a sufficient condition* , for making a luminous circumnuclear starburst. **(iii) Star formation efficiency :** We suggest that the different SFE of the starbursts and non-starbursts results from different properties of the circumnuclear gas. In the starbursts, the peak molecular gas surface density ($\Sigma_{\rm gas}$) reaches 1000 to 3500 $M_\odot$ pc^{-2} and is well correlated to the SFR per unit area (Σ_{SFR}). In contrast, the non-starbursts harbor gas-rich regions where star formation is largely inhibited. In some non-starbursts, which we denote as type I, a large fraction of the gas has an extended distribution, lies along the large-scale stellar bar or spiral arms and shows large non-circular disturbed kinematics: the low SFE is likey due to the large local shear resulting from the kinematics. In other non-starbursts, which we denote as type II, where the gas distribution is more compact and shows more circular kinematics, the low SFE likely results from the fact that the peak $\Sigma_{\rm gas}$ sems to be 3 to 4 times lower than in the starbursts, and below the Toomre critical density for the onset of gravitational instabilities.