Development of optical instruments for dust and fluid tomographic analysis in space environment

Alessandro Brunelli

Abstract

First year of the PhD work deal with analysis and laboratory tests on several instrument components such as the measurement of numerical aperture of an optical fiber for dust scatterometer, tests on the non-monolithic optical derotator for the LBT telescope (measurement of optical quality and implementation of the internal alignment procedure, test on the mirror mount and on the rotation stage) and characterization of a Pyramid wave front sensor for aberration analysis of human intraocular lenses.

Numerical models of elliptical galaxies with cosmological initial condition and magnetic fields

Umberto Buonomo

Abstract

This thesis is part of a wider program of development of EvoL, the Padova numerical TreeSPH code for the simulation of the formation and evolution of galaxies in cosmological context. The work includes an improvement of the existing code, with the introduction of new physics (e.g., magnetic fields), and the numerical optimization of parallel algorithms. Much work has been done to test the parallel version of our code in detail, using advanced debugging tools (e.g., TotalView, DDT, Gdb, and Compaq), and to improve the CPU memory management (Valgrind) and the communications between processors, to increase the speed of execution. Improvement of the code requires (in addition to the optimizations) the implementation of other physic effects. In particular, the magnetic field seems important in galaxy formation: observations indicate that its pressure is comparable in magnitude to the thermal pressure and interstellar turbulence. The complexity of the intra cluster medium demonstrates that a variety of physical processes are in action and must be included properly to produce accurate and realistic models. The full implementation of the equations of MHD, in SPH formalism, is to be completed during the first months of the next year.

Groups of galaxies: a key environment for galaxy evolution

Rosa Calvi

Abstract

Groups of galaxies are important sites to study the impact of the local environment on the diversity of galaxy properties, and are fundamental to investigate galaxy evolution. In this report I present and describe the construction of an extensive, homogeneus catalogue of galaxy groups at low redshift from the Millennium Galaxies Catalogue Redshift Survey (MGCz). About 4200 galaxies in the MGCz main sample have been considered in the redshift range between 0.03 and 0.11. Groups are identified

using an iterative procedure which mimes a friends-of-friends algorithm. $\sim$1600 galaxies are placed into groups containing at least three members in the redshift range $0.04 \leq z \leq 0.1$. The validation of the dataset came from the comparison with the 2dFGRS Percolation-Inferred Galaxy Group (2PIGG) catalogue, the largest available homogeneous sample of galaxy groups in that area.

Study of metallicity in distant galaxies // *Andrea Cardullo*

Abstract

Determination of gas metallicity in faint distant galaxies is possible using bright emission lines. The ratio of several optical emission lines is found to vary with the metallicity, and they have been directly or indirectly (i.e., through electron temperature or photoionization models) calibrated against the metallicity. Here, we take in exam the R_{23} parameter and we try to find a different calibration, which is independent of other line ratios.

Observations of the extra-solar planets with direct and indirect methods

Elena Carolo

Abstract

During the first year of my PhD I worked on the modeling technique to analyse data of the SARG Echelle Spectrometer survey (TNG, La Palma, Canary Islands, Spain) in order to obtain high precision stellar radial velocity (RV) measurements.

High redshift galaxies: theory versus observations

Letizia Cassarà

Abstract

During these last years, with the advent of modern telescopes and satellites, studies about *high redshift galaxies* are topics in great development from an observational point of view; photometric surveys allow observations of very far and faint galaxies with bigger efficiency, thus allowing to study the galactic evolution with redshift. Observations of high-z galaxies confirmed that these objects are characterized by strong UV-optical obscuration and IR emission by dust, in such a way that only taking into account all the spectral range of emission it is possible to study their properties, the SFR in particular. It is therefore mandatory to calculate evolutionary sequences of spectral models for galaxies of various morphological types including the effects of dust, both for the local universe, both for high redshift objects, to be subsequently compared with the observations.

Gas origin in the Extended Narrow Line Region of nearby Seyfert galaxies

Valentina Cracco

Abstract

Ionization cones are one of the most important evidence supporting the Active Galactic Nuclei (AGN) Unified Model. Until now, the physical processes involved in the cones are not completely understood. A still open question concerns the origin of the ionized gas, which could be ISM of the host galaxy or IGM acquired through gravitational interactions. To study the origin of the gas in the ionization cones and more generally the physical and kinematical properties of the ionized gas, we decided to study in detail two Seyfert galaxies, the Seyfert 2 galaxy NGC 7212 and the Seyfert 1.5 galaxy Mrk 6, by analyzing both integral-field and long-slit spectra, and photometric data. We will also study the properties of the ionized gas in a sample of 10-15 Seyfert galaxies as a function of the distance from the active nucleus.

Timing studies of compact objects

Claudio Germanà

Abstract

The detailed knowledge of the temporal behaviour of astrophysical objects is one of the main sources of information about physical processes occurring in several classes of objects. We observed the Crab pulsar at the Copernico Telescope in Asiago with the novel optical photon-counter AquEYE that has the best temporal resolution ever achieved in the optical domain (hundreds of picoseconds). We measured the rotational period of the neutron star with great accuracy ($\sim$ 1 ns). Using observation covering a 2 day interval in time, the measured spindown rate of the rotational period at the barycentric corrected MJD=54749.0 is 4.194×10^{-13} s/s, within the 0.6 % from the Jodrell Bank Crab ephemeris. The folded pulse shape of the Crab pulsar is confirmed to be very stable. Fast photon counters for studying rapid phenomena in the X-ray band have been built as well and have revealed millisecond time-scale modulations in the X-ray flux from Low Mass X-ray Binaries (LMXBs). This time scale is typical for matter orbiting close to the compact object. Therefore, timing studies of these sources could provide a way to investigate the motion of matter in a strongly curved space-time, thus probing General Relativity in strong field limit. In collaboration with the Department of Mathematics and Physics of the University of Ljubljana, we simulate light curves and power spectra produced by clumps of free particles orbiting a Schwarzschild black hole, that are deformed by tidal interaction. Our numerical simulations reproduce the high frequency part of the power spectrum observed in the black hole LMXB XTE J1550-564.

ISM in cosmological numerical simulations: energy feedbacks and related issues - numerical methods

Tommaso Grassi

Abstract

Modeling gas chemistry in numerical cosmology is crucial in the star formation processes. A Tree-SPH cosmological simulation must take into account a wide range of chemical species since a large chemical network is needed for the formation of the key-role molecules. However, a too detailed chemistry reduces the computational performances of the evolutionary code. This requires the development of a strategy to optimize the accuracy of the model with the computational speed. One way to approach to this problem is to create a database in advance, which would feed the data to the main Tree-SPH simulation in the running phase. In this framework we developed a code to explore the ISM and to create this database of models.

Study of the Exospheres of the Solar System Bodies

Cesare Grava

Abstract

My PhD work consists in the spectroscopic study of the exosphere of some Solar System Bodies, namely Io, Mercury and Earth's natural satellite, the Moon. These exospheres are border regions between the surface (which constitutes itself the exobase in some cases) and the interplanetary medium, so the dynamics and the cinematics of the exosphere are driven by the processes occurring at the surface (as they are collisionless) and by the interaction with the Solar Wind or the Magnetosphere. Therefore, the study of their composition and temporal and spatial variations can supply information over the crustal composition, the processes that occurred, the relationship between the surface and the interplanetary medium (or intrinsic magnetosphere, if present) and the formation of the Solar System (and, after all, of the life on Earth). To carry on this study I use ground-based spectra taken at Telescopio Nazionale Galileo (TNG) with the high resolution spectrograph SARG as well as images from the Wide Field Camera (WAC) of Osiris, onboard the spacecraft Rosetta. Most of the data are taken in the region of the Sodium doublet, as it is the most easily detectable trace element in these exospheres for ground-based observations.

Stellar evolution code with rotation

Jasna Krivicic

Abstract

The Padova group perfected the state-of-the-art of stellar evolution modelling in the uppermost Hertzsprung-Russel diagram with the release of complete set of stellar evolutionary tracks. Over recent years a number of serious discrepancies between current models and observations have been noticed. The observations show that the role of rotation has been largely overlooked. All the models outputs (tracks in the HR diagram, lifetimes, actual masses, surface abundances, nucleosynthetic yields, supernova precursors, etc.) are greatly influenced by rotation, therefore stellar evolution is basically a function of mass M, metallicity Z, and angular

velocity Ω. The implementation of rotation physics into the current code, which is the aim of our work, is crucial for obtaining the new set of stellar evolution tracks that address rotation. The first problem we faced considering the rotation is that spherical simmetry is no longer valid. In fact, the effective gravity (sum of centrifugal force and gravity) can no longer be derived from a potential and the case is said to be non-conservative. But we can still consider the problem in 1D assuming that the angular velocity is constant on isobars. This assumes that there is a strong horizontal (along isobars) turbulence which enforces constant angular velocity on isobars. This case is referred to as shellular rotation. This reflects into the code by changing the fourth equations of stellar structure. This is just the beginning and the first steps tackling the problem of rotation. The present and future work consists among others in dealing with the rotationally induced instabilities like meridional circulation, horizontal turbulence and dynamical shear and their impacts on the transport of the chemical species and on the angular momentum and their implementation into the code. The effects of rotation on mass loss can be classified in three categories, the structural effects, the effects of rotation on radiation driven stellar wind and mass loss induced by rotation at critical limit.

Cosmological survey with Herschel Space Observatory

Gabriele Mainetti

Abstract

FIR and sub-millimetric observations are fundamental for better understand the generation and assembly of stellar population in galaxies and AGN because the main star formation episods and AGN accretion happen in dust obscured environments.
In the last years, new IR and sub-millimetric data from Spitzer Telescope and BLAST helped the astronomers to better understand the galaxy formation and evolution at redshift greater than 1. For this reason, some models that well explained the ISO and IRAS results, now need an improvement. A fundamental problem in this field, is the confusion due to poor instrument resolution, typically due to diffraction (eg MIPS 70&160μm). We need hence a new tools for the analysis of the confusion-limited surveys.
I used an statistical method called P(D) distribution analysis to confirm the best-fit model developed by Franceschini et al. (2009). The method derives the probability distribution of measurements in terms of the underlying source count, which may be recovered by a model fitting model: in this way we can obtain information by sources that are much too faint to be detected as individuals. In particular I have applied this method to FIDEL ECDFS 70μm MIPS maps and also at the first Herschel SPIRE data. To have a further verification of the model, I have also applied this technique at some simulated maps.
This method applied at 70μm maps (real and simulated) confirm the best-fit model, in particular confirms the fast convergence of the counts fainter than a few mJy in the 70μm counts. For the first SPIRE data I have obtained good fit between simulated maps and real data, but the results are very preliminary. In the future I want to apply this method also a SPIRE confusion-limited maps, in particular I want to focus my attention on HerMES survey data. I will also continue the work inside the SPIRE

pipeline development: this is important also for the scientific side of my research because it allow me to have a perfect control on the all step of data reduction.

Normal and Active Galaxy Luminosity Functions based on Spitzer and Herschel Space Observatory Cosmological Surveys

Lucia Marchetti

Abstract

We have carried out a detailed investigation of statistical properties of infrared galaxies in the low-redshift universe, with the aim of establishing a local benchmark to which we could compare properties of high-redshift objects, hence establishing in a most accurate way their evolutionary properties. Namely, we combined mid- and far-infrared data from the SWIRE survey undertaken with Spitzer with data at optical and near-infrared wavelengths. In particular, we fully exploited the power of publicly available imaging and spectroscopic optical data from the SDSS database, as well as complementary near-infrared data from 2MASS and UKIDSS and further optical imaging obtained by the SWIRE team. Besides we combined SWIRE data with non-SDSS spectroscopic and photometric datasets from different public available studies. We combined these rich datasets into a unique database for studies of galaxy formation and evolution in the Local Universe. In this way we obtained a SWIRE-SDSS database jointly covering ~ 22.6 deg^2. We then selected complete and reliable samples of extragalactic sources at 24, 70 and 160 μm and discussed the overall statistical properties of the database. We finally derived the galaxy local luminosity function at 24, 70 and 160 μm using the $1/V_{max}$ estimator, and compared our results with models of infrared galaxy formation and evolution. This work puts us in an excellent position to contribute to the early science exploitation of Herschel surveys such as HerMES. The local perspective offered by SWIRE-SDSS will be extended to longer-wavelengths, higher-redshifts and larger sky areas. In this context our work provide important local benchmarks for galaxy evolution studies exploiting early Herschel data.

Planet detection with EPICS, the E-ELT Planet Finder

Dino Mesa

Abstract

SPHERE and EPICS are two instruments that are being designed to obtain images of extrasolar planets. Both of them include Integral Field Spectrograph (IFS). In this document I listed my contribution to the development of SPHERE and EPICS IFS. In particular, for what concern SPHERE IFS, I will speak about the new simulations performed taking account of the Fresnel propagation. These simulations suggest that this effect has not an important impact on the instrument performance. Moreover I will describe the procedure we adopted to analyze the data from the IFS simulations. This method will be very useful for the analysis of data provided by the real instrument too. For what concern EPICS IFS

(actualli in Phase-A) I will describe the results of the experiment about the pupil apodization and I will give some details about the optical and mechanical design of the instrument.

Optical/Infrared Supernova Searches to Probe Supernova Progenitor Scenarios

Matteo Miluzio

Abstract

The project focuses on two observational programs. The firs part of the work consists in an infrared search for supernovae in starburst galaxies, using HAWKI@VLT. The aim of this work is to verify whether the observed SN rate in sturburst galaxies (SB) is consistent with their star formation rate (SFR), the latter as deduced from the FIR luminosity. The second observational project aims to obtain an estimate of the SN rate at high redshift, using LBC@LBT to obtain repeated observations of the central part of the COSMOS field.These observations will allow to verify the unexpected decline of the type Ia SNe rate at $z > 0.8$ (GOODS SN search) and to obtain new insight on the progenitor systems of Ia SNe. The core-collapse SN rate will be used to trace the star formation history (SFH) of the Universe.

High precision transit photometry using multifiber integral-field spectrographs

Valerio Nascimbeni

Abstract

My research is focused on high-precision photometry of transiting exoplanets. We propose a new ground-based method: the use of multifiber integral field spectrographs to perform differential photometry, aiming to a precision which until now is achievable only from space. The extremely large number of photons collected by dispersing the light in a spectrum would allow us to easily reach the sub-millimagnitude regime, provided that any significant systematic trend is identified, modeled and removed down to one part over 10^4 by fully empirical algorythms. This requires the development of brand-new software tools in order to calibrate the frames and extract the spectra with an unprecedented accuracy. The final pipeline, indeed, will be useful not only for deriving high-precision light curves, but also as a new all-purpose tool for all the observations carried out with the same instrument.

Deep near infrared observations of the Magellanic System

Stefano Rubele

Abstract

My Phd project is tied to the VMC-VISTA near-infrared survey of Magellanic System (LMC,SMC,Bridge & Stream) that is one of the 6 public surveys approved by ESO to be conducted with the VIRCAM camera at the 4m VISTA telescope.
It will cover 184 deg^2 encompassing the D25 of both Clouds as well as major features delineated in the distribution of stars and HI gas, in the YJKs pass bands. The survey depth will be Ks=20.3 at S/N=10 to reach the oldest main sequence turn-off across the entire system, and will allow us to determine the spatially resolved star formation history (SFH) with unprecedented quality and to construct a detailed 3D map of the system.
The primary scope of my Phd project during the 1th and the begin of the 2nd year was in the realisation of artificial star tests and SFH-recovery tests using simulated data of VMC images, with the aim of accessing data quality and preparing the analysis pipeline.
During the last year (2nd year) we have used an adapted version of the pipeline from the VISTA survey of the Magellanic Clouds and we apply to the cluster NGC 419 (in the SMC) data the method of star formation history (SFH) recovery via CMD reconstruction, deriving for the first time this function for a star cluster with multiple turn-offs. The values for the cluster metallicity, reddening, distance and binary fraction, were varied within the limits allowed by present observations. The global best-fitting solution is an excellent fit to the data, reproducing all the CMD features with striking accuracy. The corresponding star formation rate it is provided together with estimates of its random and systematic errors. Star formation is found to last for at least 700 Myr, and to have a marked peak at the middle of this interval, for an age of 1.5 Gyr (Rubele et al. submitted).

ARCS:the Asiago Red Clump 1.22m Spectroscopic Survey

Tenay Saguner

Abstract

ESA's cornerstone mission Gaia will be launched at beginning of 2012. At the end of its mission Gaia will provide a catalog including the proper motions, parallaxes, magnitudes, object classification, and astrophysical parameters for all observed stars, galaxies, QSO, asteroids. Automated classification and astrophysical parameter determination algorithms needs to be trained on observed templates for extracting astrophysical information from the Gaia observations for the final catalog. For this aim we started the Asiago Red Clump Spectroscopic Survey (ARCS) 1.22m implementation. ARCS 1.22m derives from low-resolution (Rp=6000) optical spectra, accurate multi-epoch radial velocities with cross-corelation techniques and atmospheric parameters ($T_{(eff)}$,log$g$,[M/H]) with X^2 techniques for a selected sample of 500 Red Clump stars belonging to solar neighborhood. These results combined with astrometric and photometric external data will let us to contribute the study of galactic structure and dynamics. On the other hand with the observations of the selected catalogue red clump stars with well determined atmospheric parameters by line-by-line analiysis, let us to examine the effects of using different wavelength intervals for determining radial velocities and astmospheric parameters, to increase the efficiency and performance of the X^2 techniques.

Rotational velocity distribution problem in young clusters

Santoro Luca

Abstract

In order to study the evolution of the angular momentum of the early cloud from which the cluster generates, in my project I study the rotational velocity of the cluster stars like a tracer of the angular momentum. In this first year I give the attention on the distribution of the rotational velocity projected in the open clusters like Pleiades and Hyades. As a result, I built a procedure that starting from the observational projected rotational velocity calculates the real rotational velocity, removing the information on the inclination angle between the line of sight and the rotational axis of the single star of the young clusters.

Very fast photon counting for astronomical application

Enrico Verroi

Abstract

QuantEYE, a project carried out in 2005 for ESO, in the frame of ESO's Overwhelmingly Large Telescope, was designed to be the highest time-resolution instrument conceived to explore astrophysical variability on microsecond and nanosecond scales, down to the quantum-optical limit. On the way for OWL, in the meanwhile reduced to 42 m diameter EELT, in the last two year we designed, developed and tested a prototype of single photon detector for the New Technology Telescope, in La Silla. Iqueye divides the telescope aperture into four portions, each feeding a single photon avalanche diode. The counts from the four channels are collected by a time-to-digital converter board, where each photon is appropriately time-tagged. Owing to a rubidium oscillator and a GPS receiver, an absolute RMS timing accuracy better than half ns during one-hour observations is achieved. The system can sustain a count rate of up to 8 MHz uninterruptedly for an entire night of observation.

From 8(m) to 8(mm): wavefront sensing from cosmological to human scales

Valentina Viotto

Abstract

In the framework of my activities on characterization, implementation and integration of WaveFront Sensors (WFS), I'm going to apply the same classes of optical concepts to two apparently completely different optical systems. The first is the combination of the atmosphere with the Large Binocular Telescope (LBT), made up of two $8m$-class telescopes, and with Nirvana, the Fizeau interferometric focal station of LBT, equipped with a complex Adaptive Optics (AO) system. The second optical system is the human eye, in the framework of the ophtalmological studies on the replacing of damaged crystallines (a few les than $8mm$ in diameter) with artificial lenses. The first step I'm making about this is to perform

IntraOcular Lenses (IOL) quality tests. During the first year of my PhD I focused on the $8m$ class WFS. Nirvana is in its AIT phase, and my task was to study and define the optical setups and procedures to be used during the alignment phase, as well as actively partecipate to the optical alignment of the various systems and subsystems. An overview of the work done on this topic is given in this report.

The evolution of the galaxy mass assembly and star formation activity from z=1 to z=0 as a function of environment

Benedetta Vulcani

Abstract

The properties of galaxies change in a systematic way with galaxy mass, with redshift and with environment. Actually, we do not yet know the importance of each factor if we consider them separately. Clusters of galaxies, in relation to the large scale structure in which they are embedded, offer a unique laboratory to study the systematic variations of galaxy properties along all these three axis (mass, redshift and environment). In the last years, new large samples of clusters have been studied at z=0.5 to 1 and beyond; thanks to them, the history of clusters and their galaxies can be traced from the cluster seeds to the local Universe. At these redshifts, one of the better studied large cluster sample is the ESO Distant Cluster Survey, that observed 20 fields with clusters, groups and the field, collecting UV, optical, near-IR, IR and X-ray data. Until now, people have studied quite well galaxies in the field, determining, for example, stellar mass functions both for all galaxies and separately for galaxies belonging to the blue cloud and for galaxies on the red sequence. But no one has studied the star formation, the growth of stellar mass, the influence of the trend of the local density on galaxy mass assembly in clusters. The aim of my project of thesis is to understand the history of stellar evolution and structure development of galaxies in clusters, by tracing the star formation rate, dust content, morphology and total stellar mass of galaxies in clusters at different redshifts ($z\sim 0.4-0.8$), using both photo-z and spectroscopic EDisCS data. Then we want to compare galaxy properties at different redshifts and in different environments. For example, a first comparison of our results can be performed with the WINGS dataset, a large survey of clusters of galaxies at $0.04<z<0.07$.

During the first year of my PhD thesis I have studied the mass function of cluster galaxies. One of our goals has been to separate blue galaxies from red ones to study separately the mass distribution of star-forming and non-star-forming galaxies and then to compare them with several studies in the general field at equal redshift. We also analyzed the mass distribution as a function of morphology, local density, clustercentric distances, to understand which factors can drive the mass assembly. In the meanwhile, we analyzed the Star Formation rates by using both the IR luminosity and the luminosity derived from the [OII] emission lines. These two luminosities, that are caused by different processes, give complementary informations on the total SFR. We compared the two estimates and investigate how the star formation activity has evolved as function of galaxy mass in clusters compared to the field and groups (Vulcani et al. ApjL submitted). As we are analysing the stellar mass distributions and their evolution, we are also studying how the mass functions depends on

morphology, focusing separately on the different Hubble types. It is known that morphological types evolves with time, with spirals being much more common and S0 galaxies much rarer in distant than in nearby clusters, suggesting that many of the local cluster S0s have evolved from spirals. The evolution of the morphological types is reflected on the evolution of the mass distribution that can produce also an evolution of the distribution of the ellipticities. In fact, with a variation of the fraction of galaxies, we expect also a variation of mean ellipticity and of the distribution of ellipticity. For this reason, we are also performing a study on the distribution of ellipticities of galaxies belonging to different morphological types and at different redshifts.