MSFR Research Training Network
Contributions from Padova Observatory, Bologna Observatory and Trieste University

This document presents the proposed contributions of the Italian node to the MSFR Network. The Italian participation to the MSFR network is leaded by the Osservatorio Astronomico di Padova (the node) in tight collaboration with researchers at the Osservaotrio Astronomico di Bologna and Astronomical Department in Trieste.

1 Applicants

Alessandro Bressan (Associate Astronomer OAPD) (bressan@pd.astro.it) Local scientist in charge for the Italian node.
Percentage of research time to be invested:25%

Eugenio Carretta (carretta@pd.astro.it) (Research Astronomer OAPD)
Percentage of research time to be invested:15%

Annibale D'Ercole (annibale@astbo3.bo.astro.it) (Associate Astronomer OABO)
Percentage of research time to be invested:15%

Gianfranco De Zotti (dezotti@pd.astro.it) (Professor Astronomer OAPD)
Percentage of research time to be invested:15%

Gian Luigi Granato (granato@pd.astro.it) (Associate Astronomer OAPD)
Percentage of research time to be invested:15%

Raffaele Gratton (gratton@pd.astro.it) (Professor Astronomer OAPD)
Percentage of research time to be invested:15%

Laura Greggio (greggio@pd.astro.it) (Associate Astronomer OAPD)
Percentage of research time to be invested:15%

Francesca Matteucci (matteucci@ts.astro.it) (Professor UNTS)
Percentage of research time to be invested:15%

Paola Mazzei (mazzei@pd.astro.it) (Research Astronomer OAPD)
Percentage of research time to be invested:15%

Monica Tosi (TOSI@astbo3.bo.astro.it)(Professor Astronomer OABO)
Percentage of research time to be invested:15%

Massimo Turatto (turatto@pd.astro.it) (Associate Astronomer OAPD)
Percentage of research time to be invested:15%

2 Project Objectives

The main objectives on which the Italian team will focus are listed below.

Evolution of massive stars

Supernovae

Chemical and dynamical evolution of galaxies

Star formation history of resolved stellar populations

Spectrophotometric evolution of starburst galaxies

The formation of the Globular Clusters

2.1 Evolution of massive stars

This is a topic of interest for Padova. But it must be defined yet. In practice there is interest in analysing the effects of mass-loss from red supergiants in the evolution of massive stars (e.g. Salasnich et al. 1999) However this study could well be the result of a collaboration with other participants (Geneva, for instance) and not directly performed in Padova.

2.2 Supernovae

Supernovae explosions are able to drive winds on galactic scales which represent a key factor in the evolution of the interstellar medium(ISM), and even of the intergalactic medium (IGM). The final fate of the hot gas heated and enriched by the SNII which is observed to surround many starburst galaxies is particularly important and yet poorly known. ¿From the observational point of view, the Padova-Asiago SN group (Turatto Massimo and collaborators) is one of the leading teams in the research of supernovae related to the final evolution of massive stars, the so called Core-Collapse SNe (SNII; SNIb/c). ¿From within the collaboration of the network we expect advances in

- determination of the CCSNe frequency at different redshifts
- interactions of SN ejecta with dense circumstellar medium (SNIIn)
- underenergetic explosions, possibly arising from massive stars forming during the explosion a BH because of fallback of material.

These observations will probe to be essential for the theoretical interpretation of the interaction between ejecta, CSM and ISM and in general for our understanding of the "stellar feedback".

2.3 Chemical evolution of galaxies

The goal of the collaboration within the network, is to apply the results obtained by the new models of massive stars to study in great detail the chemical evolution of galaxies by means of very accurate models, and to interpret the abundance patterns found both in galaxies and in the IGM/ICM. To this purpose we intend to improve the galactic models already available by studying a larger number of chemical elements, by including a better treatment of the SN feedback (energy transfer from the SNe into the ISM) and 2D and 3D dynamics. With these improvements we will be able to study in more detail the development of galactic winds both in dwarf galaxies and in large spheroids (ellipticals), to predict the chemical composition of the galactic winds and the chemical and energetic enrichment expected in the IGM/ICM. With the chemo-dynamical models we will be able to study also their formation of abundance gradients both in the disks of spirals and in ellipticals. At the same time, we intend to achieve new abundance data for the bulge and the disk of the Milky Way, the elliptical and blue compact galaxies. These data will serve as database with which to compare our models. Finally, armed with good models for the evolution of galaxies of different morphological type (ellipticals, spirals and irregulars) we will be able to study the cosmic chemical evolution, namely the evolution of a unitary volume of the universe.

Important results are expected from the collaboration within the network, in the following main fields of research.

- Elliptical galaxies

  Chemical evolution models for elliptical galaxies, including the development of a galactic wind and following in detail the evolution of 20 chemical elements already exist (Matteucci and Tornambe', 1987; Bressan, Chiosi & Fagotto 1994, Matteucci, 1994; Matteucci and Gibson, 1995; Pipino et al. 2002). However, these models do not include a detailed treatment of **SN feedback** nor **an hydrodynamical treatment of the gas flows**, necessary ingredients to understand the mechanism of galaxy formation (barionic matter) and the development of galactic winds.

  During the first year of this network F. Matteucci will develop, in collaboration with **????**, a new numerical code for the chemical evolution of ellipticals including a more refined treatment of feedback from SNe in a multiphase interstellar medium, taking into account the evolution of SNR in the surrounding medium and the hot phase filling factor.

  This model, coupled with a dynamical one (see below), will provide a more defined picture of the developments of galactic winds, thus allowing us to make more robust estimate of the energy and the metals escaping from ellipticals and enriching the ICM. Moreover, ICM observations with good spatial and spectral resolution are now opening the possibility of tracing the pattern of metal enrichment and, therefore, of better connecting the ICM chemistry to the star formation history in clusters. We also intend to increase the number of chemical species followed by our code including elements at the Fe-peak (Ni, Co, Mn) and beyond (s- and r-process elements such as Ba and Eu, respectively).

  Other advances are expected in the field of the spectro- photometric evolution of ellipticals, their properties in the fundamental plane and their integrated spectral indices . The new models would be a unique tool in the study of forthcoming photometric and chemical large surveys of elliptical galaxies (e.g. Bernardi et al., 2002, SDSS; SAURON) and to set stronger limits on the theory of galaxy formation and evolution. Furthermore, the comparison between predicted and observed abundances for elliptical galaxies, through photometric indices, may be the only way to test locally the abundance pattern of elements resulting from a violent process of star formation, such as the one possibly at the origin of the formation of these spheroidals. For this reason the network (????) will provide **new stellar evolution-**

ary tracks and synthetic spectra covering the relevant values of temperatures, surface gravity, and partition of heavy elements characterizing the individual components of stellar populations.

- Spiral galaxies

  In contrast to elliptical galaxies, that are believed to form as the result of an early violent short episode, spiral galaxies are known to host a more gentle and continuous star formation activity. The different levels of activity must be clearly imprinted in the abundance pattern of the stars, as it is known from the analysis of the abundances of stars in our Galaxy. In the last years F. Matteucci and C. Chiappini developed a detailed chemical evolution model for our Galaxy (Chiappini et al. 1997, 1999, 2001), following the evolution in time and space of the abundances of 25 chemical species both in the halo and disk, as a result of two main infall episodes. Moreover, we introduced for the first time in such models a threshold gas density in the star formation process (see Kennicutt 1989).This model follows the evolution in space and time of 25 chemical species and reproduces the majority of the observed properties of the MW.

  The goal, in this network, is to **increase the number of chemical elements in the code** in order to study the evolution of more Fe- peak elements (Cr, Mn, Ni, Co) as well as s- and r-process elements and focus on studying the earliest phases of the MW evolution. In collaboration with other team of the network, we intend to compare our model predictions with the newest data at very low metallicity obtained with UVES at the VLT. Once the model is tested for the specific case of our Galaxy we can then apply it to other galaxies addressing the more general problem of disk formation.

  ¿From an observational point of view, abundances derived in PNe are particularly useful for studying the bulge of the MW, providing fundamental constraints to the formation history of the MW Bulge (Cuisinier et al. 2000, Matteucci et al. 1999). New data on PNe in the Bulge are presently under reduction (Chiappini & Cuisinier 2003, in preparation) providing an improved database for comparison with theory. Planetary nebulae can also reveal abundance gradients in disks of spirals. Our goal is to observe a sample of 50 PNe in the outskirts of the MW galaxy, to greatly increase the number of objects with available abundance measurements.

- Abundances of dwarf galaxies

  F. Matteucci also plans to measure accurate values of He/H (see Pagel 2000 for an up-to-date review) and FeIII/H in a range of blue compact galaxies (BCG) with different metallicities (including the ones with the very low metallicity). We will observe a sample of 7 objects 12+ log(O/H) in the range 7.29-7.88 with UVES at VLT (P.I. I.J. Danziger OATs). The sample will be significantly enlarged during the duration of the network. Conventional lines of H, [OIII], [OII], [NII], [NeIII], [ArIV] and [SII] will also be observed, in order to provide the N/O and C/O ratios. These ratios are very important in order to compare with the prediction of the models, since from such a comparison one can infer strong constraints on the origin of C,N and O elements. In particular, it can allow us to study the secondary/primary nature of N in massive stars, whose products are evident at low metallicities (see Matteucci, 1986). It will be also possible to derive an estimate of the primordial He and check if this abundance is consistent with the inferred upper limit of the primordial deuterium, as obtained by chemical evolution models (Tosi et al. 1998). The new measurements of He and metals will be more accurate than the already existing ones since they will have a better spectral resolution which will allow to subtract much more accurately the effect of underlying absorption and also give a better reddening correction.

2.4 Dynamical evolution of galaxies

¿From a theoretical point of view, the microphysics involved in the interaction processes between SN ejecta and surrounding medium (thermal conduction, turbulent mixing) is seldom considered in numerical simulations (only D'Ercole & Brighenti 1999 MNRAS 309, 491 used the heat conduction for some of their models), yet it is crucial to make progress in this complicated problem. Moreover, the difficulties go beyond the physics. An accurate representation of transport processes in numerical simulation requires very high resolution and hydrocodes with low numerical diffusion.

- 3D hydrodynamical simulations of ISM

  The research, leaded by Bologna and Trieste teams, focuses on multidimensional hydrodynamical simulation of ISM evolution in blue compact galaxies (BCG). Irregular and blue compact galaxies (dwarf irregulars currently undergoing a burst of star formation) are interesting objects since they are small and relatively unevolved (large amount of gas and low metal content), which must have suffered a mild and/or intermittent star formation (bursts). They are ideal objects where to study the development of galactic winds as a consequence of starbursts.

  Numerical simulations are already available in the literature and agree on the general behaviour of the ISM dynamics of starburst galaxies. However, the details are still not understood. One limitation of the models is that all (but those of Mori, Ferrara & Madau 2002) are 2D and are forced to assume cylindrical symmetry. 3D models allow to simulate more realistic stellar bursts not necessarily located at the galactic center. 3D models also allow to study the interaction of stellar winds with the ICM through which the host galaxy is moving.

  As a first step we plan to adopt a 3D code to study the effect of the ICM ram pressure on the galactic winds (Marcolini, Brighenti & D'Ercole in preparation). This problem has been considered in the past by several authors (Murakami & Babul 1999, Mori & Hensler 2000) through 2D simulations which allow to consider only not very realistic spherical galaxies. Our simulations, instead, adopt realistic models of dwarf galaxies composed by a stellar disk, a dark matter halo, and a rotating gas component in isothermal equilibrium into the potential well. While in isolated galaxies the hot, metal-rich gas may be able to cool and fall back in the galaxy, when the galaxy moves through an IGM the hot gas is dragged away. This may greatly reduce the fraction of metals retained by the galaxy. The interaction between the hot wind gas and the cold ISM regulates both the observed X-ray emission (Strickland et al. 2000) and the metal enrichment of the ISM.

  A milestone of the network will be the completion of **a new hydro code, based on a less dissipative scheme (Lax & Liu 1998), that will enable a better resolution of the contact surfaces separating the different gas phases**. This will also allow 3D simulations of multiple SNR interactions (as actually occurring in the star burst regions) in an inhomogeneous medium to understand the cumulative effects of the stellar explosions. This will cast light on the long standing problem of the SNe efficiency in heating and polluting the ISM. This study will be relevant for the understanding of the early evolution of the ICM, and the late chemical evolution of the ICM as indicated by recent XMM and Chandra data. The latter observations may be used to test the different patterns of chemical and energetic enrichment that follows from supernovae/hypernovae explosions in the different environments (Lowenstein 2001, Oh et al. 2001)

- SPH simulations of galaxy mergers

  Paola Mazzei, in Padova, is exploring the evolution of the luminous component of galaxy mergers and its dependence on general dynamical conditions, by means of SPH numerical simulations (Mazzei and Curir 2003, Mazzei 2003). It is now well established that huge star formation episodes are tightly linked with dynamical interaction. In fact, the number of interacting and merger systems increases with bolometric luminosity (Soifer et al 1988). However it is not yet clear how the induced star-burst evolves, what is its relation with the central AGN, often seen as a concomitant event, and what terminates each of the two processes. SPH simulations are an useful tool to explore the evolution of the star formation history during the dynamical interaction (Curir and Mazzei 1999). During this network Paola Mazzei will collaborate with (????) to include in the models the effects of radiative stellar winds and supernova ejecta, to perform a realistic simulation of the effects of stellar feedback. The new SPH simulations will be an essential step to model the high redshift universe where one expects a steep increases of the merging rate.

2.5 Star formation history of resolved stellar populations

Obtaining the star formation history by means of the technique of synthetic HR diagrams is by far more accurate than adopting the technique of integrated spectra, because the latter suffers of intrinsic degeneracy (e.g. between age and metallicity). Furthermore counting stars in the HR diagram allows a better quantification of both the stellar evolutionary lifetimes and the assumptions on the initial mass function (IMF). By converse the method of synthetic HR diagrams is applicable only to the nearest galaxies where at least the helium burning stars and the red giant branch stars can be resolved. In spite of this drawback, it has proved to be a very efficient method to analyse the star formation history in nearby dwarf galaxies, imaged by HST or VLT (e.g. Aloisi et al. 1999 AJ 118, 302, Annibali et al 2003 and references therein). M. Tosi in Bologna in collaboration with L. Greggio in Padova and (?????) will perform a detailed study of the star formation history in nearby dwarf galaxies by studying the colour magnitude diagram obtained with HST and VLT facilities. The technique will include the new results on the evolution of massive stars provided by the Geneva group for those galaxies showing signatures of recent activity. Not only the different levels of activity in the past will be derived, but also their spatial dependence within the galaxy, allowing a tight comparison with the predictions of chemodynamical models. This will be one of the most direct methods to study the efficiency of the star formation process and its dependence on the environmental conditions.

2.6 Spectrophotometric evolution of galaxies

In the last few years the team of the Osservatorio Astronomico di Padova has devoted significant efforts to the prediction of the "complete wavelength integrated spectrum" of the galaxies. (Bressan, Chiosi & Fagotto 1994, Bressan, Granato & Silva 1998, Silva, Granato, Bressan & Danese 1998, Bressan, Silva & Granato 2001).

The main properties of the update code (obtainable on request or at http://grana.pd.atro.it) are briefly described here and may be found in Panuzzo et al 2003 (http://www.sissa.it/ panuzzo/hii/index.html). The galaxy is described as a multicomponent system: currently we consider a disk and a bulge component with their own geometry.

- Stellar ages and metal distribution ("the population box", P. Hodge 1989, ARAA, 27, 139) are described either analytically or by means of chemical evolution code. They can also be easily provided by an external code such as a semi-analytic galaxy formation tool that generates the corresponding "population box" in a convenient format (see eg. interface with GALFORM Granato et al 2001).

- Effects of dust absorption and re-emission are taken into account in the three main different aspects:

  - dust around mass-loosing asymptotic giant branch stars (AGB) and red supergiant (RSG). This turns out to be a key ingredient for the study of intermediate age spheroidals (Bressan et al. 1988, 2001).
  - dust in star forming molecular complexes. A "time dependent" fraction of the most recent star formation history (SFH) is supposed to be enshrouded within molecular clouds (MC). They are specified by a mass and radius (a family of MCs is also possible) that, together with the optical properties and size distribution of dust grains define the "optical depth" of the MCs which is one of the key parameters in the model. The radiation transfer problem is solved (point source) and the corresponding UV-Optical attenuation and emission at mid infrared (MIR), far infrared (FIR)and sub-millimetric (S-mm) wavelengths is computed.
  - dust in the diffuse "cirrus" component

    The other fraction of the SFH is supposed to generate stars that are already outside MCs but that may be attenuated by a diffuse cirrus dust component. The radiation transfer problem (taking into account emission from MCs) is solved and the volume emissivity is computed and integrated to provide the luminosity of the galaxy (from far UV to S-mm), at different inclination angles. Surface brightness maps are also possible but not computed.

- Gas emission.

  Nebular emission is added making use of a library of pre-computed HII regions with the code CLOUDY (Ferland 1990). HII regions are supposed to form around young stars (within or outside MCs following the geometry described above), and lines and continuum emission are attenuated accordingly (see Panuzzo et al 2003).

- Geometry

  The geometry of the stars and diffuse dust may be independently specified for each component. The geometry of a single molecular cloud is spherical with the young star cluster at the center. MC's are distributed as the stars of the same component.

- Radio emission.

  Radio emission from simple stellar population completes the prediction of the continuum emissivity beyond the sub-millimetric regime. It is assumed to be the sum of free-free emission from electrons within HII regions and synchrotron emission from relativistic electrons accelerated in the interaction processes of ejecta of core collapse supernovae (CCSN) and the environment (Bressan, Silva & Granato 2002). Non-thermal radio emission is set proportional to the CCSN rate, with a scaling law obtained from our Galaxy (e.g. Condon 1992). Additional effects, such as synchrotron emission from young SN remnants, are roughly evaluated and are found to contribute not more than a few percent to the non-thermal emission. Radio emission combined with sub-millimetric and FIR ($\lambda\ geq\ 100\mu$m) probes to be fundamental to disentangle the starburst and AGN contribution in obscured infrared luminous galaxies (LIRGs) and it is possible the only method to analyse the star formation processes occurring in luminous high redshift galaxies.

  Given the importance of a correct prediction of radio emission from star formation processes, a **milestone of the network is to obtain a realistic model for electron acceleration** during the interaction process of CCSN ejecta with the circumstellar and interstellar medium, in particular for the environment of a violent star formation process.

- Molecular emission.

  In collaboration with Olga Vega (INAOE, Mex) we have considered the emission from molecules (eg ^{12}CO and ^{13}CO) at several sub and millimetric transitions. A large velocity gradient (LVG) code has been added and can now be used to predict line emissivity of several other molecules. The interface may make use of the parameters derived for the molecular clouds (metallicity, radius, density) in order to maintain consistency with the global fit of the galaxy SED.

  Currently the kinetic temperature of the gas is given as a parameter. A **milestone of the network is to provide a realistic model for the energy balance between gas, dust and cosmic rays** that allows a consistent prediction of the kinetic temperature of the clouds in different regimes of star formation activity with obvious application to high redshift galaxies.

- X-ray emission from simple stellar populations.

  The recent discovery of a tight relation between FIR or Radio emission and 2-10 Kev X-Ray emission in starburst galaxies, shows that objects related to young stars may constitute a significant source of hard X-Ray emission. A census of the possible cases (Vanbeveren and ....) highlights the importance of accreting massive X-Ray binaries, young thermal supernova remnants and very young pulsars. Silva, Granato & Bressan (2001) have attempted to include the contribution of these objects in the general population synthesis code. As a result of this study, however, it turns out that the uncertainties inherent in our understanding of the most advanced phases of single stellar evolution and of binary stellar evolution, largely affect the reliability of the theoretical predictions. Suffice here to recall that recent determination of the X-Ray luminosity functions in a few external galaxies reveals the existence of very luminous sources, without counterpart in our Galaxy. This eventually implies accretion onto very massive compact objects that are however difficult (or even impossible) to obtain in the context of the current evolutionary scenario of massive stars. A possible alternative is that these sources are young CCSN remnants resulting from extremely energetic events.

In this field, another **milestone of the network would be a more exhaustive inclusion of the effects of binary evolution in population synthesis codes**. This will essentially provide a way to compare with of 2-10Kev X-Ray luminosity functions of nearby starburst galaxies and with the total of 2-10Kev X-Ray emission in more distant objects.

- Interface of the synthesis code.

  One of the noticeable features of the GRASIL code is its easy interface with different blocks of the general population synthesis problem.

  We have already commented on the different possibilities to specify the star formation history and metal enrichment law. In particular the use of the "population box" formalism, makes it very easy to interface the code for integrated properties with those for the synthesis of resolved systems (HR diagram simulation tools like the "Padova Software Telescope" ???? or the analogous one provided by researchers in Bologna).

  Another key feature is the possibility of using SSPs based on different spectral libraries. After a convenient conversion to a proper format, data by different authors may be used as spectral libraries. The code adapts itself to the new data set and outputs the results on the new wavelength dominion. This renders very easy to study particular problems (e.g. high resolution models of massive stars in the UV) or to evaluate uncertainties brought by the use of different stellar and spectral libraries.

- Semi-analytic models of galaxy formation.

  One of the most interesting applications of new insight of violent star formation processes, is the study of the galaxy evolution within a cosmological context. This is achieved by the technique of semi-analytic models of galaxy formation, where an "ab-initio" scenario of hierarchical merging of dark matter halos is coupled to the assembly of barions in galaxies. To this purpose one of the most interesting aspects is the feedback from the massive stars (UV radiation, stellar winds and SN explosions) and the eventual feedback from the QSO. The stellar feedback and the feedback of the QSO may operate simultaneously, but at different intensities, in the galaxies of different size. A recent model for the combined early evolution of E-type galaxies and QSO has been proposed by Granato et al 2003.

  An improvement of the model will be the inclusion of detailed chemical end dynamical models of galaxies, because this will allow to study the nature of high redshift objects such as DLAs, Lyman-break and SCUBA galaxies within the same framework.

  As a part of the project, a collaboration between Padova, Trieste and (??????) is meant to compare the predicted [alpha/Zn,Fe] versus [Fe,Zn/H] as well as [alpha/Fe, Zn] versus redshift with the available data. From this comparison we will be able to infer the nature and the age of high redshift objects. This method has been already applied with success to DLAs by Calura et al. (2003) who concluded that the majority of these systems should be either external regions of galactic disks or irregular galaxies either such as the LMC or such as BCGs. As a specific project of the network, we intend to develop a statistical methodology by adopting the most detailed and accurate semy-analytic models for the interpretation of a significant sample of DLAs.

- Analysis of large data sets.

  With the advent of large observational data sets (e.g. Sloan Digital Sky Survey, SDSS http://www.sdss.org/) it has become mandatory to combine the most update population synthesis tools into fast algorithms for the statistical analysis of the observations. We have already developed a simple tool for the population synthesis study of galaxies of any type. The code combines SSPs with different strength and attenuation and find the best fit model by minimizing a suitable merit function based on different observables such as narrow or broad band magnitudes and equivalent widths of absorption and emission lines (Poggianti, Bressan & Franceschini 2001, analysis of optical spectra of Very Luminous Infrared Galaxies). A recent improvement o the code has been made in collaboration with INAOE (Mayya, Bressan et al 2003, optical and NIR properties of M82-like galaxies). The code has not yet been applied to large data sets and actually suffers from being still too slow for this purpose. **A milestone of the network is the definition of new fast algorithms for the analysis of large data sets**. This project has been recently started as a collaboration between INAOE and people in Padova and Cambridge. The project aims not only at finding new fast algorithms but also to highlight the spectral regions that contain the optimal information on the age and metallicity of the stellar populations. We have already found that the detailed profiles of the higher lines of the Balmer lines (and nearby continuum) contain a critical information for the intermediate age population and, at the same time, the detailed shape of the CaK line is very sensitive to the presence of populations older than a few Gyr (Terlevich et al 2003). For this reason we have also started a project to compute high resolution stellar atmospheres as described below.

- High resolution spectral models.

  The wavelength resolution of population synthesis codes is limited by that of the corresponding stellar atmosphere libraries adopted. Libraries with the highest resolution (R$\simeq$3000 in the optical) are based on empirical observations with the drawback of a general scarce coverage of the fundamental parameter space, wavelength, T_{eff}, gravity and metallicity. For this reason, in collaboration with INAOE we started a project to obtain high resolution (R=50000, degradable to the required resolution) model spectra within the framework of the Kurucz library. High resolution spectral synthesis models are particularly useful for the analysis of the absorption features around the Balmer discontinuity and allow a fair characterization of the mixture of intermediate and old age stellar populations. This in turn is fundamental to constrain the extinction properties of the young population and consequently a correct determination of the recent star formation history of the galaxy.

2.7 The formation of the Globular Clusters

Observations of external galaxies show that significant populations of globular clusters may form during strong dynamical interaction phases, characterized by violent star formation (see e.g. Schweizer & Seitzer 1993). On this respect, it is interesting to note that studies of relative ages of the globular clusters of our own galaxies (Rosenberg et al. 1999) suggest that they may be divided into two age groups: the first one has a very old age, and it is probably related to the very early phases of formation of our own Galaxy, just a few 10^8 yr after the Big Bang. This group includes the most metal-poor known globular clusters. The second group, that essentially coincides with the group of *thick disk* clusters first suggested by Zinn (1985), is likely a couple of Gyrs younger. The possible connection between this second group and the thick disk would be very interesting, since the thick disk is now thought to be originated by the heating of a preexisting disk due to some quite strong dynamical interaction (see the review by Freeman & Bland-Hawthorn, 2002); this is confirmed by the presence of clear chemical differences between the thick and the thin disk populations (Gratton et al. 1996, 2000; Fuhrmann 1998). This hints that the population of *thick disk* globular clusters of our Galaxy, including classical examples like e.g. 47 Tucanae, may be originated in the same violent phases that created the thick disk, and possibly stopped star formation in our Galaxy for a while, before formation of the thin disk.

The following important points are worth being addressed by the network collaboration

- The age differences between different groups of globular clusters should be confirmed by independent methods: this is now possible due to progresses in distance/age estimators (main sequence fitting method, dynamical distances, white dwarf cooling sequence).
- A better characterization of the peculiarities of globular cluster chemical abundances may help to understand their mechanisms of formation.
- The role of the galactic bulge, one of the most significant populations of our Galaxy, should be better established. It might be that a significant fraction of the bulge population formed within the same violent phase that possibly lead to the thick disk formation.

Our proposed research tries to better establish all these points, exploiting the availability of powerful instrumentation at ESO, combined with data provided by HST.

3 Required human resources

Given the large field of interests of the Italian community we intend to ask for a Post-Doc and a PhD student.

- 1 Post-Doc (3 years) The Post doc should mainly work in the field of spectro-photometric population synthesis taking the responsibility of including the new proposed advances in the domain of the evolution of massive stars, interaction of SN ejecta with the CSM and ISM, and chemo-dynamical models, made by the network partners. It will also organize the code for its use among the partners, also by making the necessary training and dissemination of results in the other nodes.
- 1 PhD student (3 years) The PhD student will be trained in the analysis of the star formation history of resolved stellar populations. Data reduction and use of interpretative tools will bee his main fields of employment. With the first item we intend to train the student to an independent ability in the observational research while te second goal is meant to stimulate his interest in the domain of the theoretical approach. At the end of his training he will take care of the interface between the new chemodynamical models and the HR simulations of nearby dwarf irregular galaxies.

Secondment of young researchers from other nodes will also be requested. In particular we need a strict collaboration with nodes working on massive star and binary star evolution, stellar atmospheres, hydrodynamic of SN explosions and analysis of large data sets.

4 Brief description of the Italian node and sub-nodes.

- Padova, the main node.

  Padova hosts the Osservatorio Astronomico di Padova and Asiago (Istituto Nazionale di Astrofisica, INAF) and the Department of Astronomy of the Padova University. They can open PhD training positions and Postdoc fellows. There is also a tight connection with the International School for Advanced Studies (SISSA, Trieste, that can also open PhD positions and Postdoc fellows) where some of us (A. Bressan, G. De Zotti and G.L. Granato) have regular PhD lectures in Astrophysics.

- Bologna.

  The two astronomical Institutions in Bologna (Department of Astronomy and Bologna Observatory-INAF-) can open training positions (fellowships and PhD) for foreign students provided funds are available. Students participating to the above projects will have access to several workstations and to the facilities of the Cineca Supercomputer Center. The students will be supervised by the proposers of the present projects. Also some students of ours are available to spend some time in foreign Institutions.

- Trieste.

  The Department of Physics of the Trieste University can open PhD training positions and Postdoc fellows. There is a tight connection with the International School for Advanced Studies (SISSA, Trieste) where F. Matteucci has regular PhD lectures in Astrophysics. There is also a tight connection with people from the Osservatorio Astronomico di Trieste (INAF).