———— MSFR Research Training Network ————
Geneva Observatory

1 Science objectives

Numerous astrophysical topics from gamma-ray burst and high redshift galaxies to stellar evolution, asteroseismology and extra-solar planets are being studied at the Geneva Observatory.

Regarding the topics covered by the present proposal the Geneva Observatory is particularly renowned for being among the world leaders in the field of stellar evolution, covering in particular various fields such as the evolution of massive stars and stellar nucleosynthesis (AM, GM, CC). Furthermore it has a strong expert team on the modeling of galaxy dynamics and the interstellar medium in galaxies (lead by DP), and also specialists on stellar clusters (team of JCM). It now also hosts a new young research team on "Massive Star Forming Regions from the local Universe to high redshift" under the direction of the node coordinator (DS). This team is in particuliar expert in several topics including the multi-wavelength modeling of massive star forming regions and observations and analysis of young starbursts.

Taken together the researchers of this node are able to provide especially state-of-the-art models for the evolution of massive stars from their birth to before the supernova explosion, their individual spectra by means of stellar atmosphere models, synthesis models of stellar populations including also the emission from the ionised interstellar medium (synthesis code + photoionisation codes). Stellar evolution models for low and intermediate mass stars including numerous physical processes (rotational mixing, transport mechanism related to gravity waves and soon magnetic fields) also provide important predictions concerning their contribution to integrated spectra of older populations and their essential nucleosynthetic production of various elements (e.g. N). All these models represent fundamental tools for the interpretation of most observations of massive star forming regions. They are also a crucial input for other simulations/codes used by various members of the network and for the astrophysical community at large.

1.1 Science projects and work plans

- **Physics of Super Star Clusters and tests of stellar evolution: [PhD thesis or post-doc, year 1-4]:** Schaerer (GE), Lehnert, Mengel (Munich). Possibly: Lancon (Strasbourg), de Grijs (Sheffield): in-

clusion of new stellar tracks with rotation in evolutionary synthesis codes, study of implications on stellar populations studies of MSFR, application to young and intermediate age extragalactic star clusters, tests for synthesis models, studies of IMF from spectral and dynamical measurements.

The first part of this work (year 1 and possibly 2) will be dedicated to the distribution of recent stellar evolution models to various groups of the network and their implementation in different simulations (synthesis codes).

- **The earliest phases of Super Star Clusters: the hidden mid-IR to sub-mm view [post-doc, year 1-4]:** Schaerer, Martin-Hernandez (GE), Stasinska (Paris), Sauvage, Madden (CEA), Morisset+? (Mexico), Bressan, Granato (Italy): Detailed multi-wavelength modeling of HII regions and photodissociation regions. Comparisons with "global" galaxy models (Italian group). Applications to optical to sub-mm observations of embedded super star clusters and young starbursts including future observations with new Mexican LMT (sub-mm) telescope.

- **Nucleosynthesis predictions from new generation stellar models and their impact on the chemical evolution of galaxies [PhD thesis preferred, year 1-4]:** Charbonnel (GE), Prantzos (IAP), Tosi (Bologna) Computation of a new generation of stellar evolution models including the effects of rotation, internal gravity waves, and magnetic fields. Predictions on their contribution to integrated spectra of olf populations. Detailed study of the corresponding nucleosynthesic production of both light and heavy elements, and various applications relative to the chemical evolution of stellar clusters and galaxies. Strong coupling with observational programs with multi-object sprectrographs on 8-10m class telescopes.

2   Synergies and legacy projects

The proposed collaborations within the network can already build upon various existing mid- or long-term collaborations with members of other proposed nodes. The most important ones among them are:

- Schaerer, R. Gonzalez Delgado (Granada), Stasinska (Meudon/Paris): studies of metal-rich extragalatic HII regions (abundances, stellar content, IMF)

- Schaerer, Stasinska (Meudon/Paris): combined starburst and photoionisation modeling

- Schaerer, Meynet, Cervino (Granada, LAEFF): evolutionary synthesis modeling, gamma-ray observations of the Galaxy (joint projects on INTEGRAL with CESR/Toulouse)

- Schaerer, Contini (Toulouse): Wolf-Rayet galaxies

- Schaerer, Heydari-Malayeri (Paris), Deharveng (Marseille): Study of compact massive star forming regions in the LMC and SMC

- Schaerer, Martin-Hernandez, Sauvage (CEA): mid-IR observations of compact HII regions and young starbursts

- Schaerer, Martin-Hernandez, Morisset (UNAM Mexico), Bouret (Marseille): photoionisation modeling of compact HII regions

- Schaerer, Kunth (IAP): observations and modeling of Lyman-alpha emission in starbursts (collaboration to be started in 2003)

- Charbonnel, Prantzos (IAP), Tosi (Bologna): impact of new stellar yields on chemical evolution modeling

- Meynet, Pettini (Cambridge): origin of nitrogen

New cross-network collaborations:
[some of them will possibly be split up in several sub-groups]

- Schaerer (Switzerland), Cervino, Gonzalez-Delgado (Spain), Crowther, Smith (UK), Fritze v. Alvensleben (Germany), Lancon, Fioc (France), Bressan, Granato (Italy): evolutionary synthesis codes and models including new stellar physics (stellar tracks, atmospheres, high resolution stellar libraries, ...)

- Schaerer (GE), Lehnert, Mengel (Munich). Possibly: Lancon (Strasbourg), de Grijs (Sheffield): young and intermediate age extragalactic star clusters, tests for synthesis models, studies of IMF from spectral and dynamical measurements

- Schaerer, Martin-Hernandez (GE), Stasinska (Paris), Sauvage, Madden (CEA), Morisset+? (Mexico), Bressan, Granato (Italy): Detailed

multi-wavelength modeling of HII regions and photodissociation regions. Comparisons with "global" galaxy models (Italian group). Applications to optical to sub-mm observations of embedded super star clusters and young starbursts including future observations with new Mexican LMT (sub-mm) telescope.

- Schaerer (GE), Crowther, Smith (UK): spectral synthesis and applications to Wolf-Rayet galaxies

- D. Burgarella (Marseille), D. Schaerer: Lyman Alpha emission from galaxies. We will observe two or three fields (HDFS, CDFS, AXAF) with GIRAFFE on VLT (PI : Denis Burgarella) to detect the Lyman alpha emission of starbursting galaxies in two redshift ranges around z=2.5 and z=3.5. ...

2.1 Legacy for RTN members and astrophysical community

Models made available to RTN members and community (during and after existence of network):

- stellar evolution models including latest physical ingredients (mass loss, diffusion, rotational mixing, transport mechanisms due to gravity waves, magnetic fields) [GE]

- stellar atmosphere models for massive stars (non-LTE lineblanketed models including stellar winds) [GE, Sheffield, Munich]

- evolutionary synthesis models including latest stellar physics [various: GE, Granada, Goettingen, Paris]

- combined evolutionary synthesis and photoionisation models for young starbursts [various including GE]

- state-of-the-art evolutionary synthesis codes [various including GE]

- chemical evolution models including up-to-date stellar yields [various including GE]

3 Geneva as a host for network trainees

3.1 Environment and main research areas

The Geneva Observatory is part of the University of Geneva and is intimately linked to the Institute of Astronomy of the Swiss Federal Institute

of Technology in Lausanne (EPFL), formerly attached to the University of Lausanne. Both institutes are responsible for the teaching and research in astrophysics in the Physics and "Basic Sciences" departments respectively. Together they represent a unique center for excellence in astrophysics in the French part of Switzerland with an excellent world-wide reputation.

The main research topics covered at these institutes are:

- Extra-solar planets

- Stellar variability and asteroseismology

- Stellar evolution and nucleosynthesis

- Physics and dynamics of galaxies

- Massive star forming regions

- High energy astrophysics and AGN

- Observational cosmology (from 2004 on)

3.2 Training

Training in most areas of astrophysics is provided at the Geneva Observatory. The topics covered include: High Energy Astrophysics and Space Astrophysics, Stellar Structure and Evolution, Complements of Stellar Physics, Structure and Evolution of Galaxies, and Radiation Transfer and Spectral Diagnostics in Astrophysics. In particular, PhD students are obliged to follow 5 lectures over one year and pass written and oral examinations in 3 of them. Three of these lectures are given by members of the proposed node (AM, DP, DS). These post-graduate lectures leads to a title of "DEA" (Diplômes d'Etudes Approfondies).

PhD students also frequently participate at international schools on various topics and attend the well-known yearly Saas-Fee Advanced Course in Astrophysics organised by the Swiss Society of Astronomy and Astrophysics including regularly staff of the Geneva Observatory.

Since it's existence, numerous students have made their studies at the Geneva Observatory leading to a PhD degree of the University of Geneva. Sufficient members of team are formally entitled (AM, DP, DS) to direct PhD thesis of the Geneva University.

3.3 Management know-how

The Geneva Observatory has been involved in various European and other international collaborations (Scope: research collaboration Swiss-Ukraine, duration 4 years; two INTAS research projects; the European "NACRE" collaboration Nuclear Astrophysics Compilation of REaction Rates). It is currently a node in a FP6 RTN network on Planet Formation and a parter in the FP6 Integrated Infrastructure Program "OPTICON" as a participant in the Joint Research project and the Network activities on Optical Interferometry.

The responsible scientist for this node (DS) has been and is the coordinator (PI) of two INTAS research projects (1997-2000, and new project submitted in 2003) involving 5-6 teams from the same number of countries. He was also responsible for a French-Spanish "PICASSO" collaboration (2000-2001) funded by the French and Spanish Ministeries for Foreign Affairs. He also administers the funds for his new research group financed by the Swiss National Foundation.

4 Previous information from GE node

RTN "Violent Star Formation"

Geneva Observatory node

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update: 14 april 2003, DS

Coordinator:

Prof. Dr. Daniel Schaerer (daniel.schaerer@obs.unige.ch) - hereafter [DS]

Proposed collaborators: Dr. Corinne Charbonnel (corinne.charbonnel@obs.unige.ch) [CC] Prof. Dr. Andr Maeder (andre.maeder@obs.unige.ch)[AM] Dr. Georges Meynet (georges.meynet@obs.unige.ch)[GM] Prof. Dr. Daniel Pfenniger (daniel.pfenniger@obs.unige.ch) [DP] Dr. Leticia Martin-Hernandez (leticia.martin@obs.unige.ch)(post-doc) [LMH] Dr. Jean-Claude Mermilliod (jean-claude.mermilliod@obs.unige.ch) [JCM]

possibly also: Prof. Dr. Thierry Courvoisier [TC] Prof. Dr. Andr Blecha [AB]

Header information

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name: Daniel surname: Schaerer alias: DS node: 6 email: daniel.schaerer@obs.unige.ch keywords: stellar atmospheres, stellar populations, star formation, HII regions, galaxies, modeling and observations collaborators: AM, GM, DP, LMH, Gonzalez Delgado (Granada), Stasinska (Meudon/Paris), Cervino (Granada, LAEFF), Martin-Hernandez, Sauvage (CEA), Morisset (UNAM Mexico), Kunth (IAP)

name: Corinne surname: Charbonnel alias: CC node: 6 email: corinne.charbonnel@obs.unige.ch keywords: stellar evolution, nucleosynthesis, chemical evolution collaborators: AM, GM, Prantzos (IAP), Tosi (Bologna)

name: Andre surname: Maeder alias: AM node: 6 email: andre.maeder@obs.unige.ch keywords: stellar evolution, nucleosynthesis collaborators: GM, CC, DS

name: Leticia surname: Martin-Hernandez alias: LMH node: 6 email: leticia.martin@obs.unige.ch keywords: star formation, HII regions, IR,mid-IR,radio observations collaborators: DS, Sauvage (CEA), Morisset (UNAM Mexico)

name: Jean-Claude surname: Mermilliod alias: JCM node: 6 email: jean-claude.mermilliod@obs.unige.ch keywords: star clusters collaborators: CC, AM, GM, DS

name: Georges surname: Meynet alias: GM node: 6 email: georges.meynet@obs.unige.ch keywords: stellar evolution, nucleosynthesis collaborators: AM, CC, DS, Cervino (Granada, LAEFF), Pettini (Cambridge)

name: Daniel surname: Pfenniger alias: DP node: 6 email: daniel.pfenniger@obs.unige.ch keywords: galaxies, hydrodynamic simulations, cosmology collaborators: DS

Domains of expertise:

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- Stellar modeling: * stellar evolution models for massive, intermediate and low mass stars including mass loss, stellar rotation, and gravity waves [AM, GM, CC]

* stellar atmospheres and radiation transfer: atmosphere models for O stars including stellar winds, non-LTE effects, and line blanketing [DS]

- Nucleosynthesis, stellar yields: * hydrostatic phases of massive stars (pre-SN modeling in progress) [AM, GM] * nucleosynthesis origin of CNO, Ne, 26Al and related elements/isotopes in the proto-solar nebula, the local interstellar cloud, meteorites, stars, Galactic regions, and extragalactic objects [AM, GM, CC] * studies of the primordial Li and 3He abundances, nucleosynthesis in intermediate and low mass stars, stellar abundances in globular clusters and Local Group galaxies [CC]

- Evolutionary synthesis modeling: * development of multi-wevelength synthesis codes [DS] * combined starburst - photoionisation modeling [DS] * ISM radiation transfer modeling (in progress) [DS]

- Studies of stellar populations: * (resolved) massive star populations in Local Group galaxies [AM, GM] * multi-wavelength studies of Galactic massive star forming regions (gamma, UV, optical, IR, radio) [DS] * massive star populations in starbursts, UV-optical studies of Wolf-Rayet galaxies [DS] * mid-IR studies of young starbursts [LMH, DS]

- Stellar clusters: * WEBDA Database of Galactic Open Clusters [JCM] * analysis of young stellar clusters and confrontation with stellar evolution models [JCM, GM] * spectroscopic studies of stars in galacic globular clusters [CC]

- N-body and hydrodynamical modeling: * galaxy modeling [DP] * collapse models combining hydrodynamics, gravity, chemistry and radiation transfer [DP]

Involvement in observational/instrumental projects related to RTN

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- High energy astrophysics: * PI of INTEGRAL Science Data Center (ISDC) hosted by the Geneva Observatory [TC]

- FLAMES/VLT: CoI institute, group of [AB]

- KMOS/VLT: member of consortium, and member of science team of near-IR multi object spectrograph "KMOS-2" proposed for 2nd generation instrumentation on VLT [DS]

Proposed topics for research and formation

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Possible in main domains of expertise listed above, in particular: - stellar evolution modeling including diffusion, rotation, gravitational waves, and magnetic fields - radiation transfer modeling in galaxies - combined photoionisation and dust emission modeling - mid-IR studies high resolution of starburst galaxies - stellar population studies of nearby to distant starbursts (observations and modeling) - chemical evolution studies

Also: - high redshift starbursts and Population III objects (modeling and observational programs) - hydrodynamic modeling of SF in early Universe

For all topics studies at the pre- or post-doctoral level can be proposed.

Most of these topics could greatly benefit from shared expertise with other proposed RTN members within and beyond ongoing collaborations. This includes both expertise with observations and modeling.

Main ongoing collaborations with members of other proposed nodes —
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- Schaerer, R. Gonzalez Delgado (Granada), Stasinska (Meudon/Paris): studies of metal-rich extragalatic HII regions (abundances, stellar content, IMF)

- Schaerer, Stasinska (Meudon/Paris): combined starburst and photoionisation modeling

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—end of information Geneva node