CIFIST Marie Curie Excellence Team
Initial Outline Report

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1 Scope of this document

This report has the purpose of providing a snapshot of the situation under which the CIFIST team (contract No. MEXT-CT-2004- 014265) is beginning to operate. It summarizes the outcome of the Kick-Off meeting which took place in Paris on September 8th 2005, of which the programme is provided in appendix A and list of participants in appendix B. The plans for the first six months of operation of the team are also laid out.

2 Scientific Background

In this section, I outline the general scientific background underlying the CIFIST project as well as the status of relevant on-going researches carried out by team members and members of the GEPI.

2.1 Introduction

About 13.7×10^9 years ago, the Universe emerged from a hot and dense phase, the so called "big bang". In the first three minutes, before the cosmic expansion cooled too much the Universe, nuclear reactions took place which lead to the formation of nuclei of ^{2}H, ^{3}He, ^{4}He and ^{7}Li, but none of the more massive nuclei. The Universe had then what is believed to be the "primordial" chemical composition, i.e. essentially only H and He with traces of deuterium and lithium.

About 4×10^5 years after another significant event took place, namely the recombination of H, due to the cooling of the Universe. After which the Universe became essentially transparent. The record of this event is constituted by the photons on the last scattering surface, which we presently observe, redshifted, as the Cosmic Microwave Background.

At a later time, which is not precisely known, but should be in the range of 10^6 to 10^8 years, the material of this primordial composition could condense locally and form the first generation of stars. The significance of these first stars is double: on the one hand they were a source of UV photons capable of ionizing hydrogen and thus contribute to the re-ionization of the Universe; on the other hand they are the first source of complex nuclei, usually improperly called "metals" by astronomers. Both these facts have an important bearing on the galaxy formation process and the subsequent history of the Universe.

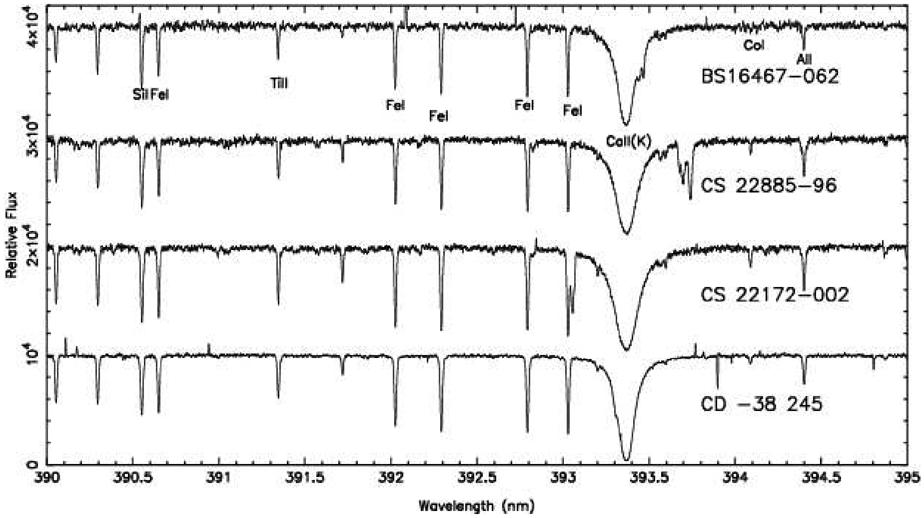

Figure 1: A portion of the spectra of the four most metal-poor stars known today, from François et al. (2003). The weakness of the metallic lines denotes the extremely low abundance of metals, which is here at the level of 10^{-4} of the solar value.

There are four main questions concerning the first stars which we would like to answer:

1. when did they start to form ?
2. what were their masses ?
3. how many UV photons did they produce ?
4. what nuclei (chemical elements) did they form and what proportion of each (abundance ratios) ?

If a star of 0.8 $M_{\odot}$ had been formed 14×10^9 years ago it would still be shining on the Main Sequence today and its atmosphere would constitute the fossil record of the primordial chemical composition. In spite of extensive searches in the last thirty years no such star has been observed. There are theoretical arguments by which such stars could not form and in fact the first stars could have been all very massive and be by now extinct (see e.g. Ferrara 2003, MSAIS, 3, 198 for a review). However also counter arguments exist (see e.g Nakamura & Umemura 2002 ApJ, 569, 549) and it may still be that such stars can be found but they have so far escaped our searches.

What has been found in the Galactic Halo are stars with a metal content which is 10^{-4} that of the Sun and ages above 13×10^9 years (see e.g. François et al. 2003, A& A 403, 1105). Even though these objects cannot be the first stars, their chemical composition reflects the products of the first stars and has the potential of constraining many of the properties of these stars (masses, modes of explosion etc.) Moreover the ages of these “second generation stars” represent a lower limit for the formation of the first stars.

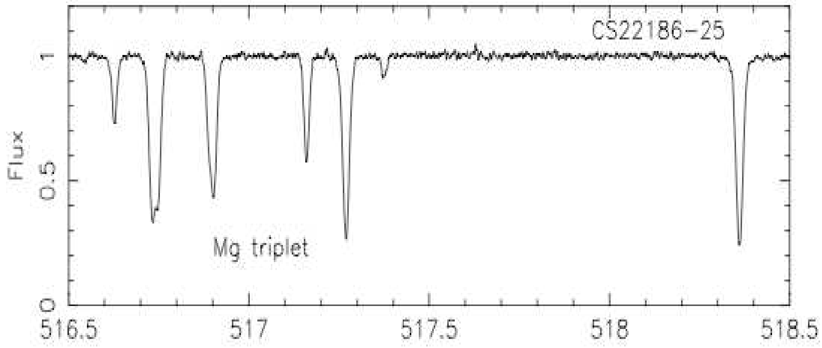

Figure 2: The UVES spectrum of the Mg I b triplet in the metal-poor giant CS 228186-25 of V=14.24 demonstrates the excellent quality of the data acquired in the course of the LP First Stars.

2.2 The First Stars Large Programme

“First Stars” was a Large Programme (hereafter LP) of the European Southern Observatory, whose full title was “Galaxy Formation, Early Nucleosynthesis, and the First Stars” and has been led by R. Cayrel. It was allocated 38 nights on the Very Large Telescope over 4 observing periods. Besides R. Cayrel the team was composed by J. Andersen (DK), B. Barbuy (BR), T.S. Beers (USA), P. Bonifacio (I), E. Depagne (F), P. François (F), V. Hill (F), P. Molaro (I), B. Nordström (DK), B. Plez (F), F. Primas (ESO), F. Spite (F), M. Spite (F).

Several of the goals of the Large Programme were common to those of the CIFIST team.

The large collecting area of VLT and the efficiency of UVES allowed to acquire spectra of unprecedented quality for such faint stars, an example is shown in Fig. 2.

The results of the LP have been so far presented in a series of six papers on the European Journal Astronomy & Astrophysics and one letter to Nature, three more papers for Astronomy & Astrophysics are in preparation and will be submitted before the end of the year.

One outstanding result of the programme has surely been the discovery of a star with extremely low metallicity in which the abundance of uranium could be measured. The significance of this finding is that, since U is radioactive and its half life is known, the measurement of its present day abundance allows to measure the time elapsed from the synthesis of the element. In practice one uses the ratio of two neutron capture elements, which are produced in the same conditions and whose production ratio can be derived from theory. The ratio U/Th proved to be extremely robust, in the sense that it depends little on the details of the physical conditions prevailing during the nucleosynthesis process. This led to an estimate of the age of the star CS 31082-001 of $(14.0 \pm 2.4 \times 10^9)$years (Hill et al. A&A 387, 560).

Another extremely important result of the programme has been that the abundance ratios, like [Mg/Fe], [Si/Fe],...[Co/Fe] have a very well defined variation with metallicity, as measured, e.g., by [Fe/H] or [Mg/H]. At any given metallicity the scatter in any of these abundance ratios is fully explained by the observational errors leaving no space for any intrinsic scatter. On the contrary for neutron capture elements like Sr, Y, Ba... there is a large scatter (of 1 dex or larger) in the ratios like [Sr/Ba], at any given metallicity. This second finding implies that the gas in the early Galaxy was poorly mixed. In order to reconcile this with the uniformity of abundance ratios of the lighter elements it is necessary to postulate that either the stars which contribute these elements span a very small range in mass, contrary to the current understanding of the Initial Mass Function (IMF), or that the yields of these elements vary little with the mass of the star producing them, contrary to current theoretical predictions.

The First Stars programme has been highly successful, however many things remain to be done, and some of these may be accomplished by the CIFIST team:

- solve the discrepancy between the Li abundance predicted by standard big bang nucleosynthesis with the baryonic density measured by the WMAP satellite and the observed Li abundance in metal-poor stars:
- understand what was the IMF of the primordial stars;
- Observe nowadays true Pop III stars in their Supernova or Gamma Ray Bursts phase;
- understand the extremely Fe-poor and C-rich objects like HE 0107-5240;
- substantially extend the sample of known extremely metal-poor stars.

2.3 Problems with lithium

The lithium abundance is linked to the density of baryons in the Universe, but also to many other problems and researches relevant to the CIFIST team. Let us name here only the problem of extra mixing in giant stars, the abundance anomalies in globular clusters, the lithium in some binary stars, and the 3D-NLTE modeling of stellar atmospheres as a whole.

As mentioned in section 2.1 the most straightforward interpretation of the Li plateau is that it represents the Li produced during the big bang. One reason for this is that metal-poor stars are characterized by convection zones which are much shallower and more superficial than solar-metallicity stars, for any given temperature. This suggests that in metal-poor G dwarfs Li should be preserved, contrary to what happens in the Sun, where Li is depleted by more than two orders of magnitude with respect to what is found in meteorites, which represent the original composition of the solar nebula. In the Sun the convection zone is deep enough to mix in the atmosphere material which has been in zones with temperature in excess of 2×10^6K, where lithium has been destroyed by nuclear reactions ("burnt").

The first idea which comes to our mind to reconcile these values is that Li is indeed depleted in the atmospheres of these stars, by some mechanism not included in standard models (turbulent diffusion, rotation, gravity waves,....). However, the observed uniformity of the lithium plateau poses a very serious constraint on any of these mechanisms, all of which tend to predict some intrinsic scatter in the plateau. Figure 4 shows the sample obtained in the course of the First Stars programme (Bonifacio et al. 2005, IAU Symposium 228, Cambridge University Press, in press), which is the one with the largest number of stars below [Fe/H]=-3.0. The plateau seems extremely uniform.

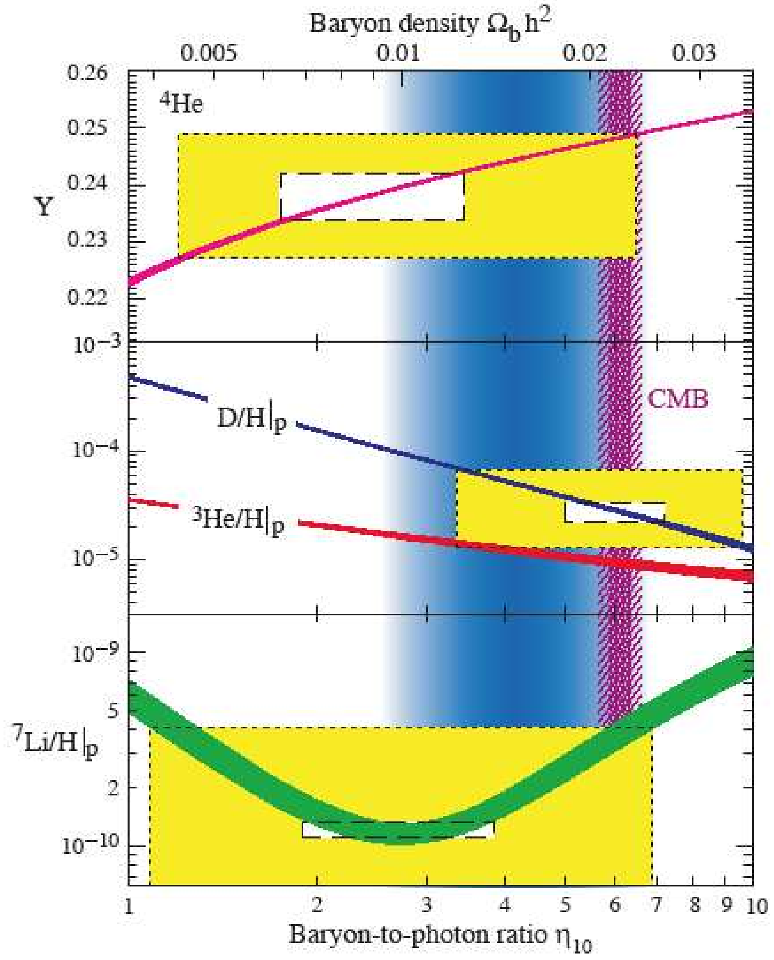

Figure 3: The predictions of Standard Big Bang Nucleosynthesis (SBBN) for various values of the baryon-to-photon ratio, η. The magenta band on the right represents the value of η, with its error, measured by the WMAP satellite, through the fluctuations of the Cosmic Microwave Background. The Li abundance predicted by SBBN for this value of η is higher than what observed in Halo stars almost by a factor of three.

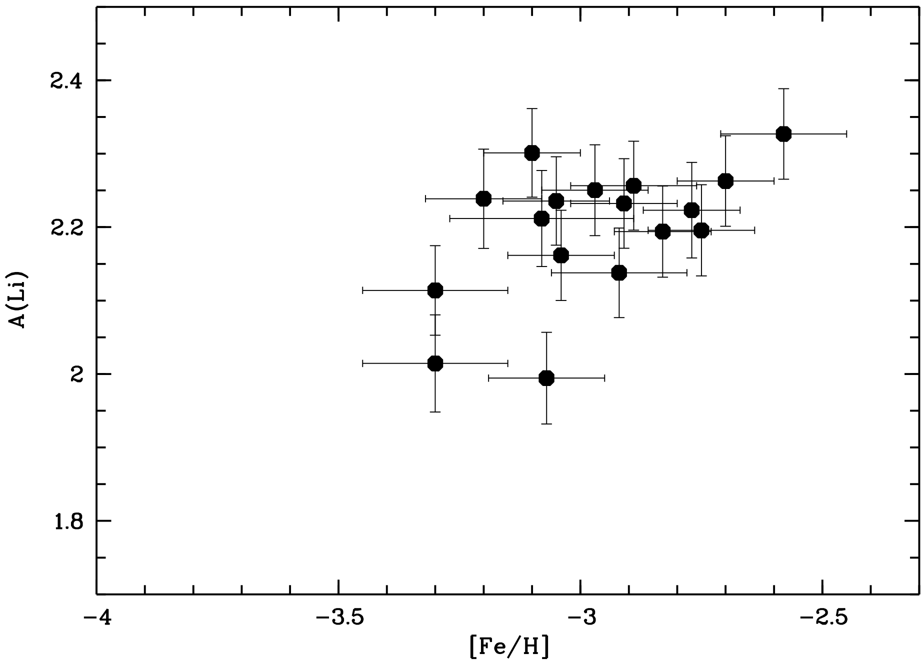

Figure 4: The observations of Li in Turn Off stars by the First Stars programme. The paucity of stars at extremely low metallicity is obvious.

The need for observations of a larger number of stars is clearly apparent. However also an improved modelling of the stellar atmospheres is important. It could well be that at least a part of the Li-WMAP discrepancy is due to a systematic error introduced by our current 1D modeling.

2.4 Carbon and nitrogen in extremely metal-poor stars

After H, He and O, C and N are the most abundant elements in the Sun. Their formation mechanism in supernovae is not well unerstood. They can be observed in metal-poor external galaxies, something which demands the availability of a Galactic comparison.

In Fig. 5 the stars observed in the course of the First Stars programme are shown in the $T_{\rm eff}$,log g plane and compared to a theoretical isochrone. The sample consists of 34 giant stars, of which 17 "unmixed", and 18 TO stars. The chemical composition of the atmosphere of dwarfs and unmixed giants has not significantly changed since the birth of the star. Therefore they can be considered as true fossil records of the chemical composition of the early Galaxy.

As far as the C abundances are concerned we noted a systematic difference between unmixed giants and TO stars. The reasons of this are unclear at the moment. It may be that the "first dredge up" actually enriches the atmosphere in C, or it may be that the 3D effects, so far not included in model atmospheres of giants, are smaller for giants than for TO stars.

Another unexpected finding is that extremely metal-poor stars are found to have rather low O/C ratios. In fact since O is synthesized only in high mass type II SNe, while C is synthesized in stars of all masses (also in type Ia SNe) one expects a high

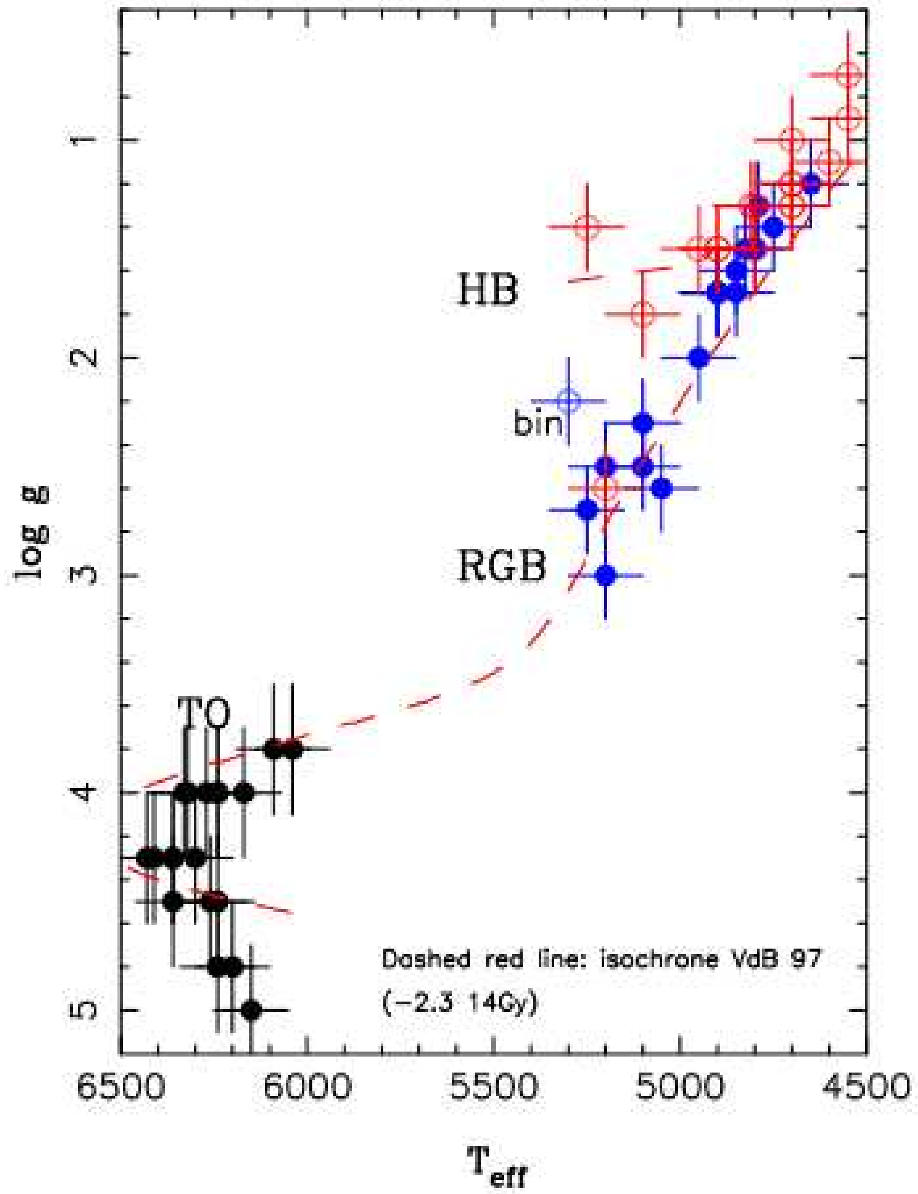

Figure 5: The effective temperatures and surface gravities of the stars observed in the First Stars programme. Mixed giants are shown in red, unmixed giants in blue and TO stars in black. The dashed line is a theoretical isochrone with an age of 14 Gyr.

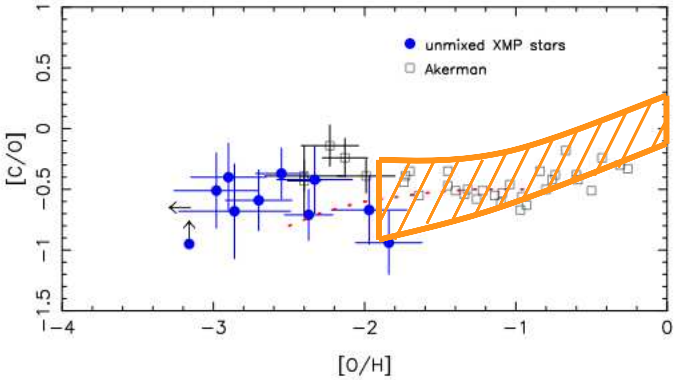

Figure 6: C/O ratios in stars compared to the data of extragalactic HII regions (shaded area).

O/C ratio in low metallicity stars, in which Type Ia SNe did not have time to contribute, given their longer timescales. In fact there appears to be a good agreement among O/C ratios in stars and in galaxies (HII regions), as shown in Fig. 6.

The conditions for the nucleosynthesis of nitrogen are different, it is produced during the pre-supernova phase through the CNO cycle and should behave as a secondary element, in that its production should depend strongly on the metallicity of the SN progenitor. In this situation one expects a very low [N/Fe] at low metallicities and a rising [N/Fe] at higher metallicities. In the First Stars sample, N can be measured only in giants, from the NH band at 336 nm, which is too weak in dwarfs. The situation is complex, there seems to be a constant value of [N/Fe] at very low metallicity, which would prompt for a primary production of N (e.g. through mixing by rotation in massive stars), however there appear to be also stars with very low [N/Fe] which show a secondary-like behaviour. The number of unmixed giants observed is too small to draw definitive conclusions, however also in this case it is obvious that observations of more stars are badly needed. In the case of N, the 3D effects are totally unexplored and this is a serious concern for the presently available measurements. Hopefully the 3D models which shall be computed within the CIFIST project, will allow us to put the N abundances on a firmer basis.

2.5 Heavy elements in extremely metal-poor stars

The elements more massive than Zn, i.e. beyond the "iron-peak", cannot be synthesized by nuclear fusion, which becomes in fact an endothermic process, since for the heavier nuclei the binding energy per nucleon decreases for increasing mass of the nuclei. The processes which allow to manufacture these elements, usually referred to as "heavy elements", are the neutron captures. After capturing a neutron a nucleus is usually prone to undergoing β decay, to descend into the so-called $\beta-$stability valley. Accordingly, the neutron capture processes are divided into *slow* (s) or *rapid* (r) depending on whether β decay occurs before or after a new neutron capture. Quite obviously the neutron fluxes necessary for the r-process are considerably larger than those for the s-process.

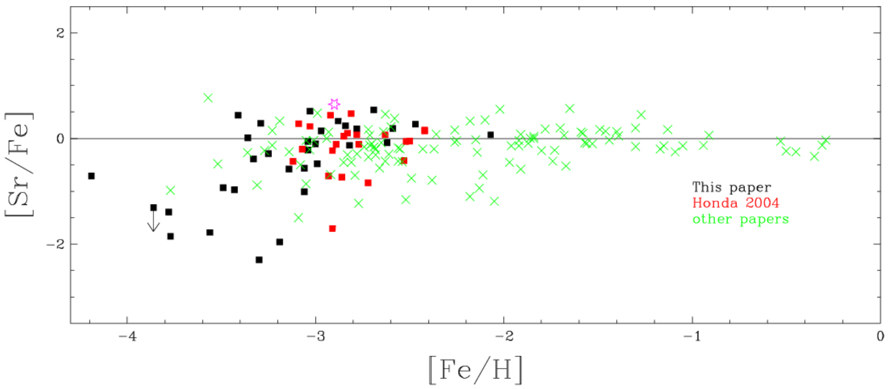

Figure 7: Results of the First Stars programme on heavy elements. The scatter is real and not due to observational errors.

The astrophysical site where the *s*-process is believed to take place is the intershell region of Asymptotic Giant Branch (AGB) stars.

The site of the *r* process is still unknown, but almost certainly associated to the explosion of type II SNe. More exotic hypothesis, such as neutron star mergers, though physically plausible, provide predictions which are in disagreement with the observations.

The study of heavy elements in metal-poor stars was pioneered by Spite & Spite (1978, A&A 67, 23) who found that [Ba/Fe] and [Y/Fe] were decreasing with decreasing [Fe/H]. On the basis of this observation Truran (1981) put forward the hypothesis that this implied that at low metallicity the heavy elements are synthesized only by the *r*-process. The reason for this should be simply one of time scales: AGB stars do not have time to evolve and disperse the heavy elements produced by them before the type II SNe have significantly increased the overall metallicity of the interstellar medium. Therefore extremely metal-poor stars should show only the products of *r*-process.

In the last twenty years of the last century, many more observations were carried out, confirming the trends found by Spite & Spite (1978), however the picture which emerged was characterized by the presence of a very large scatter in the measured abundances of the heavy elements. Most of the metal-poor are very faint ($V > 13$) which makes it quite challenging to observe them with 3m class telescopes. Moreover very few lines could be measured for each element. Many lines lie in the near ultraviolet range, which was either not accessible, or accessible with a very low efficiency, from most telescope/spectrograph combinations. The situation drastically changed with the advent of UVES at VLT. This spectrograph was explicitly designed to provide a high efficiency in the UV, which coupled to the large collecting area of VLT allowed the First Stars programme to collect data of an unprecedented quality. The results are summarized in Fig.7. It now appears clear that the intrinsic spread is real and also that the spread increases with decreasing [Fe/H]. A lack of stars with high [X/Fe] (where X is any heavy element) below [Fe/H]~ -3.2 has been remarked. The *r*-process signature, as suggested of Truran (1981), has been confirmed. The decreasing trend of the [Sr/Ba] ratio implies the necessity to invoke a second *r*-process, favouring the lighter heavy elements (weak *r*-process).

Another field in which UVES+VLT has brought substantial progress is the study of the heavy elements in Globular Clusters (James et al. 2004, A&A 414, 825 ; 2004, A&A 427, 825). Globular Clusters are self-gravitating systems which are essentially coeval with the Halo stars, although they are not as metal-poor as the most metal-poor Halo field stars. In this case the quoted studies show that there are no abundance variations for heavy elements at different evolutionary phases, which implies that Globular Cluster stars were formed by material which was already enriched in n-capture elements. Moreover there appears to be no correlation between abundance anomalies and the synthesis of *s*-process elements, which poses some strong constraints on the models invoking pollution by AGB stars. Finally, an abundance variation with metallicity is found showing that Globular Clusters show the same abundance patterns as field stars at the same metallicity.

The use of FLAMES at VLT, with its high multiplex capability will allow to extend these results to statistically significant numbers of stars.

2.6 The search for *r*-process enhanced metal-poor stars

The Hamburg-ESO R-process Enhanced stars Survey (HERES, Christlieb et al. 2004, Barklem et al. 2005) is aimed at the discovery of these rare, extremely metal-poor objects. The scientific goals are to use these objects for nucleocosmochronology and to explore the nature and the astrophysical site of the *r*-process.

The starting point of HERES is the Hamburg-ESO Survey, which is based on objective prism plates and goes one magnitude deeper than the HK Survey (Beers et al. 1985 AJ, 90, 2089; 1992, AJ 103, 1987). Candidates have been selected from this survey and observed with UVES at resolution $R = 20000$ and S/N$\sim$ 50 with the spectral coverage 376-498 nm. It observed 373 stars, mainly giants and the spectra were analyzed in an automatic fashion. A quick measure of the Eu abundance allowed to pick up the *r*-enhanced stars.

Two categories of stars were evident, the *rI* stars which are only moderately *r*-enhanced and the *rII* stars which were strongly *r*-enhanced. The difference of the two groups of stars is made clear in Fig. 8.

Of the 373 stars only 274 could be analysed automatically of these 8 were found to be *rII* stars and 35 *rI* stars. While *rII* stars are found only around metallicity ~ -2.8 *rI* stars are found at all metallicities.

For one of the *rII* stars, CS 29497-004, there is a possible detection of uranium, however, although the *r*-enhancement in this star is quite substantial ([r/Fe]=+1.6, to be compared to [r/Fe]=+1.7 for the famous CS31082-001), it does not show the "actinide boost", which makes it more difficult to measure U. These findings question the universality of the *r*-process and perhaps we should be looking for a variety of sites for the *r*-process.

Some of the stars studied by HERES and are not *r*-enhanced, but rather "normal" metal-poor giants and dwarfs, but of extremely low metallicity, may prove to be very interesting targets for the CIFIST team.

2.7 Extremely metal-poor stars in dwarf galaxies

In hierarchical galaxy formation scenarios, large galaxies form from small pre-existing systems, ancestors of dwarf spheroidal (dSph) galaxies that merge together. It is therefore interesting to compare the oldest, primitive population in dSph galaxies to that in large spirals. Primitive objects are expected to be found in small galaxies!

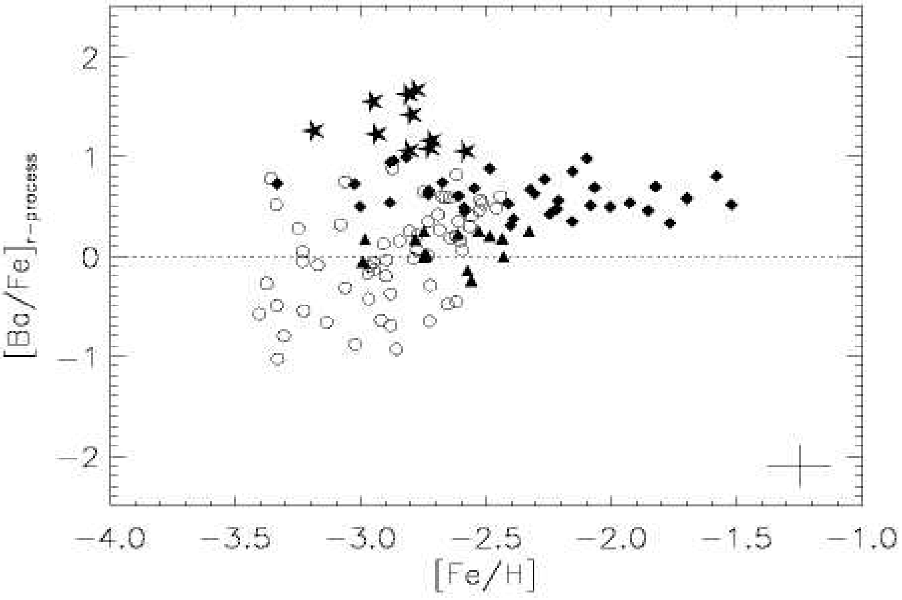

Figure 8: HERES project, the *rII* and *rI* stars.

Another reason for studying the dwarf galaxies is to asses their role in the formation of the Galactic Halo. The outer halo is filled with tidal streams, are these the remnants of disrupted dwarf galaxies that remain coherent in phase space? (Bullock et al. 2002, Font et al. 2001, 2005, Johnston et al. 2002, etc.) Are the thick or thin disk the result of merging dwarf galaxies? (Abadi et al. 2003, Steinmetz et al. 2002, Navarro et al. 2004, 2000, Brooks et al. 2005, Helmi et al. 2005, etc.)

The DART (Dwarf Galaxy Abundances and Radial Velocities Team) is a VLT+FLAMES programme aimed at the study of the galaxies Sculptor, Fornax, Sextans and Carina. Its strategy is to obtain the dynamics, dark matter and [Fe/H] estimate for the galaxies from low resolution spectra of the infrared Ca triplet, and then, for about 100 confirmed radial velocity members in the central regions, to obtain the chemical evolution and star formation history from high resolution spectra.

A programme is now starting to try to find the metal-poor tail of the population of these four galaxies.

A parallel effort is being pursued by P. Bonifacio and collaborators to map the metal-poor tail of Sagittarius and a star candidate to have [Fe/H]~ -3.0 has already been observed at high resolution. In the case of Sgr, which is a very large galaxy and is also very extended, because it is very near, an extremely large number of stars is needed. In this case the high multiplexing capabilities of VIMOS have been used to observe at low resolution the infrared Ca triplet.

2.8 3D model atmospheres, available models, and codes.

A stellar atmosphere is a physical system which is characterized by the effective temperature, the surface gravity and its chemical composition. In general, the chemical analysis of stellar atmospheres is based on time-independent one-dimensional models assuming the conditions of hydrostatic and thermal equilibrium. The stars which are of interest for the CIFIST project possess convective envelopes, which drive gas flows also in the optically thin atmosphere. This generates inhomogeneities in horizontal direction, i.e. deviations from 1D symmetry, and often the resulting mean vertical stratification differs from predictions from standard models. Rerlated to this the stellar atmosphere shows substantial deviations from hydrostatic and thermal equilibrium. Moreover, the gas flows are non-stationary, i.e. real stellar atmospheres are in fact time-dependent.

The radiation-hydrodynamics code CO^{5}BOLD is available to the CIFIST team and will be used in the course of the CIFIST project to calculate detailed atmospheric models including the gas-dynamical processes mentioned above. CO^{5}BOLD solves the equations of compressible hydrodynamics in two or three spatial dimensions, including the handling of shocks up to moderate Mach numbers. It solves the equation of radiative transfer taking into account the wavelength dependence by a multi-group approach. It also has the capability of following the non-equilibrium chemistry of trace species, e.g. necessary to model the formation of CO molecules in the Sun. At present CO^{5}BOLD does not take into account stellar rotation. All in all, the code is suitable for modelling stellar atmospheres and chromospheres, and the resulting models rest on a sounder physical footing than the ones obtained within the 1D approach. We expect that CO^{5}BOLD models help to obtain stellar abundances of high fidelity. The benefits of the multi-dimensional modelling comes at the expense of substantially higher computational costs, and in particular for metal-poor atmospheres the models are in an early stage of their development.

Another computer code which will be used is called LHD which is a 1D Lagrangian radiation-hydrodynamics code. It will be mainly used to for producing stationary atmospheric models serving as comparison models with the multi-dimensional CO^{5}BOLD models. The point is that LHD uses exactly the same microphysics (equation-of-state, opacities) as CO^{5}BOLD, convection is treated with the standard mixing-length theory. This allows a strictly differential comparison between the 3D models and effectively standard models. In this way the 3D effects can be singled out without being blurred by the effects of different assumptions concerning the microphysical model input.

The spectral synthesis calculations can be performed using LINFOR_3D. This code allows the spectral synthesis of line profiles of time series of 2D and 3D data blocks, both for disc-center and disc-integrated intensity. At present the code assumes local thermodynamic equilibrium (LTE), a single species can be synthesized at the time and a rather simple line broadening theory is applied, which means with the present version H-lines cannot be appropriately synthesized.

The stars of interest to the CIFIST project occupy a well defined area in the $T_{\rm eff}$-log g plane, shown in Fig. 9 as shaded area. The area is only very scarcely populated by existing models. It is clear that considerable work has to be invested to increase the number of available models. In addition, some improvements have to be implemented in the existing codes: the kind of possible input opacities of the multi-group radiative tranfer scheme will be enlarged, a line synthesis option including non-LTE effects for the multi-dimensional models will be developed, and possibly an improved broadening theory will be implemented in LINFOR_3D to the allow the synthesis of H-lines.

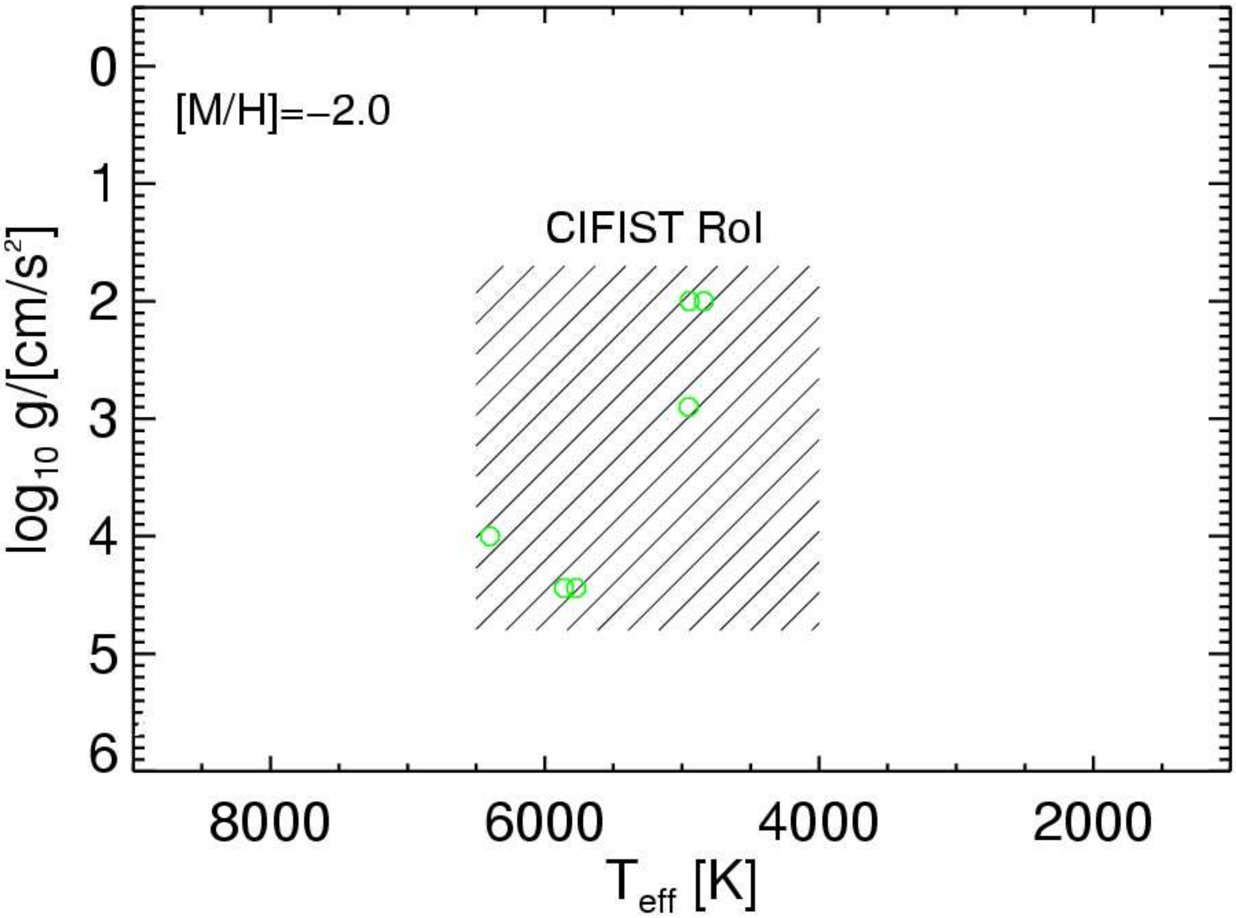

Figure 9: The area of interest to the CIFIST team in the T_{eff}-log g plane. Currently available 3D models are shown as circles.

2.9 Chemical composition of secondary stars in LMXBs: implications on the progenitors of black holes and neutron stars.

A Low Mass X-ray Binary (LMXB) is composed of a compact object (neutron star or black hole) and a late type star (dwarf or giant) which is transferring mass to the compact object feeding an accretion disc. The compact object is clearly the end product of the evolution of a massive star which exploded as a supernova, ejecting its nucleosynthesis products in the interstellar medium.

There is a number of outstanding issues on the evolution of massive stars:

1. Convection and rotation in massive stars
2. Mass Cut in SN explosions
3. Amount of fallback in the SN
4. Possible mixing during the collapse
5. Energy of the SN explosion
6. Symmetry of the SN explosion

some of these can be tackled by the study of the chemical composition of the companion star in a LMXB. Inasmuch as the surface of this star has been polluted by the ejecta of the supernova it can provide important information on the supernova yields.

J. González-Hernandez has been tackling this problem for his PhD thesis at the Instituto de Astrofísica de Canarias. So far two systems have been studied in detail: A0620-00 (González-Hernández et al. 2004, ApJ 609, 988) and Cen X-4 (González-Hernández et al. 2005 A&A 435, 1185, González-Hernández et al. 2005 ApJ 630, 495). Both systems are very faint, fainter than V=18, which makes the observations very challenging.

For A0620-00 moderate anomalies for Ti, Ni and especially Al exist, suggesting a pollution by the SN. A comparison with spherically symmetric SN explosion models suggests that the secondary star captured part of the ejecta. The measured abundances can be explained from a 14 $M_{\odot}$ He core progenitor with a mass cut in the range 11-12.5 $M_{\odot}$. O, Mg, Si, S and C will be studied to confirm this scenario.

For Cen X-4 Fe, Ca, Ni, Ti and Al show abundances slightly higher than solar. The large Galactic space velocity of the system might suggest a non-spherical SN, however elemental abundances can only be explained by a spherical explosion of a 4 $M_{\odot}$ He core progenitor.

Both systems show a Li abundance which is very high for their effective temperature. In normal stars as cool as these, the extended convection zone effectively depletes the Li in the atmosphere. This high Li abundance indicates either that they are very young systems and there has not been time to deplete Li, or that a Li preservation mechanism exists. There is also the possibility of Li production either in the accretion disc or through spallation on the stellar surface. For Cen X-4 there is a preliminary measurement of the Li isotopic ratio equal to the meteoritic ratio, this would essentially rule out the Li production hypothesis.

2.10 The CODEX experiment

The COsmic Dynamics EXperiment (CODEX) is an instrument for the OWL, the Over Whelming Large optical telescope of 100m diameter which is under study at ESO.

The primary aim of CODEX is to perform for the first time a direct measurement of the cosmic dynamics. The basic idea behind CODEX is, deceptively simple: if you measure the redshift of an object now and in 10 years time, you should detect an increase in redshift, due to the expansion of the Universe. In practice this requires the measurement of a radial velocity with an accuracy of 1 cm/s over an interval of 10 years. This is about two orders of magnitude better than what is possible today. However extensive simulations have shown that this goal can be achieved, provided a high enough S/N ratio can be obtained.

The current baseline for CODEX is to obtain spectra at a resolution of $R \sim 150000$ and S/N$\sim$ 2000 for QSOs, and use the lines of the Lyα forest as probes of the cosmic expansion.

Besides the main objective of the experiment it is clear that such a powerful spectrograph can be used with a significant impact also for other scientific objectives. For example CODEX will be able to measure ^{6} Li and ^{7}Li in extremely metal-poor stars in our Galaxy and in our nearest neighbours.

The current design foresees the use of an array of highly stable high resolution fibre-fed spectrographs working in the range 400-680nm. For a 100m telescope the aperture on the sky should be of 0.7 arcsec, which becomes 1 arcsec for a 60m telescope.

The foreseen time-scale for CODEX is to be ready in 2017, therefore well after the CIFIST project is over, however in the current project concept it appears necessary to build a full-scale prototype of a Unit Spectrograph of CODEX for the VLT (CODEXino) prior to building a full-scale CODEX for OWL. The reason for this is, that radial velocity studies to this level of accuracy are unprecedented. To demonstrate that the desired performance can be attained, it will be necessary to integrate the technical solutions that were developed or tested stand-alone in a full-scale prototype.

CODEXino should be ready in 2009, shortly after the end of the CIFIST project, however, the science goals which can be achieved with this prototype instrument can be significantly enhanced by the results of the CIFIST team. For example if CIFIST has succeeded in the identification and measurement of significant numbers of extremely metal-poor stars, some of these can be targeted by CODEXino at a resolution $R \sim 200000$ to measure crucial isotopic ratios, such as the Li isotopic ratio. The development of the 3D modeling done for the CIFIST project will prove to be of fundamental importance for the interpretation of the extremely high resolution spectra delivered by CODEXino.

2.11 The GAIA mission and possible synergy with CIFIST

GAIA is a cornerstone mission of the European Space Agency science programme. Its key objective is to determine the origin and history of our Galaxy. It consists of 3 instruments:

- an astrometric instrument;
- a photometric instrument (4 wide bands + 11 intermediate bands)
- a spectrograph (Radial Velocity Spectrometer – RVS).

The launch is foreseen at the end of 2011 and the release of the catalogue around 2019.

The scientific motivations for the RVS are

- measurement of radial velocities;

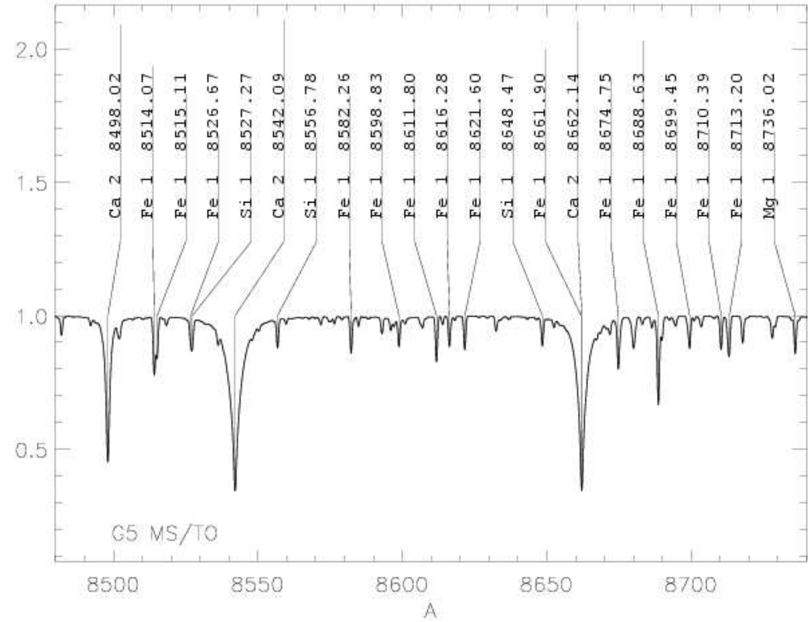

Figure 10: Simulated RVS spectrum for a G5 V star of solar metallicity.

  - coupled to the proper motion and parallax measurements (obtained from the astrometric instrument) allows to obtain the three dimensional space velocity of the individual stars, which will allow us to reconstruct the kinematical and dynamical history of the Milky Way;
  - detection of binary and multiple systems and determination of their orbits;
  - correct the astrometric data from perspective acceleration

- atmospheric parameters and chemical abundances
  - chemical history of the Milky Way
- interstellar reddening
- stellar physics
  - rotational velocities
  - variability
  - mass loss

The concept of the RVS is that of an integral field spectrograph operated in Time Delay Integration (TDI) scan mode. The resolving power will be $R \sim 11500$ and the spectral range 857-874 nm. The strategy is that of a multi-epoch scan providing about 80 observations for each object.

At the end of the mission the RVS will provide radial velocities for about 1×10^8 stars with $V \leq 17$ rotational velocities for about 2.5×10^7 stars with $V \leq 15$, stellar parameters for about 10^7 stars with $V \leq 14$ and chemical abundances for 5×10^6 stars with $V \leq 13$.

GEPI is deeply involved in the GAIA mission, namely in the preparation of the on-board and on-ground data analysis system. This includes

1. on board processing;
2. simulation of the satellite observations;
3. analysis of the astrometric data;
4. calibration and analysis of the spectroscopic data;
5. analysis of the double and multiple systems.

It is mainly for task 4) that there exists a strong overlap and synergy with the CIFIST team. This concerns the atomic and molecular data (oscillator strengths, damping constants...) a topic on which the GAIA team can take advantage of the results of the CIFIST team; it is also very important for the RVS to have observed reference spectra and the CIFIST team will be in the position to provide unique spectra of extremely metal-poor stars; finally all the improvements in the atmospheric modeling and computation of synthetic spectra, including 3D and NLTE physics, obtained by the CIFIST team will prove to be of great importance for the analysis of the RVS spectra.

2.12 General lines of future development

In spite of the impressive effort which has been conducted in the field of extremely metal-poor stars there is a lot of work which still needs to be done and in this section I outline some of the general lines along which the CIFIST team will direct its action

2.12.1 Physical modeling of stellar atmospheres

What is observed are not abundances or abundances ratios, but stellar spectra. Abundances and other physical parameters (effective temperatures, surface gravities,...) are derived by comparing the observed spectra to computed spectra derived from physical models of the stellar atmosphere. It is therefore clear that the derived abundances are only as good as is the model we used to derive them. Up to now state of the art one dimensional model atmospheres have been used for this purpose. These ignore the three dimensional structure of the atmosphere and phenomena such as granulation, which we observe directly in the Sun and should also be present in other stars. There is no way to decide *a priori* whether such effects are important or not. It is necessary to perform self consistent three dimensional computations and compare the results with the one dimensional computations. Some 3D model atmospheres exist and also 3D codes, however they have, so far, not been used extensively for the analysis of metal-poor stars also because the heavy computational demand of 3D hydrodynamics and 3D radiative transfer. Therefore there is considerable scope both for the computation of 3D models and for their development and improvement, adding more physical ingredients.

2.12.2 Study of unevolved stars of extremely low metallicity.

These stars are potentially very interesting, mainly because their chemical composition is surely unaltered (which is not always the case for giants) and also because they are hot enough that they may have preserved their original abundance of the cosmologically relevant element lithium. However in the work so far carried out the unevolved stars are the most-poorly studied class: fewer stars, fewer elements and isotopes studied for each star. This is due on the one hand for the intrinsic faintness of these stars, compared to giants, thus for a given magnitude limit one is sampling a much smaller volume for dwarf stars than for giants; on the other hand the spectra of dwarf stars are characterized by weaker lines than those of giants of the same metallicity, therefore both the observations are more difficult and one has fewer spectral ones with which to work. There is therefore a strong need to study more unevolved stars and to study in more detailed already known ones.

2.12.3 Spectroscopic binaries of extremely low metallicity

The study of these stars is complicated by the need to disentangle the spectra of the two companion stars, this needs more observations and a time consuming analysis. However the information potentially available from these systems is of great importance. In fact from the orbital data it is possible to derive information on the masses of the stars, which is a datum of crucial importance for the stellar evolution theory. Few such stars have been analysed to date, and even for those better data is now available. Therefore there is considerable scope for the study of these binary systems.

2.12.4 New searches for metal-poor stars

New impulse for the search for metal-poor stars is coming from new available surveys and new instruments. The Sloan Digital Sky Survey (SDSS) (http://www.sdss.org) has already provided low resolution spectra and five colour photometry for over one hundred thousand stars. Its continuation SDSS-II SEGUE (Sloan Extension for Galactic Understanding and Exploration) will provide similar data for other 250000 stars. This data allows the search of extremely metal-poor stars (or even primordial stars, if they exist), however suitable algorithms for selection and analysis of the data have to be developed. Of course after suitable candidates are selected it will be necessary to follow-up with high resolution observations. The exploitation of the SDSS current and future data certainly requires a considerable amount of work.

Another possibility, which is worth exploring, is provided by ”pencil-beam” surveys which can be performed with instruments such as FLAMES on the VLT. In such a survey one covers a small sky surface but goes very deep, so that the surveyed volume is large. A pilot project on this concept has been carried out at VLT, showing that useful spectra for stars as faint as V=20 can be obtained. These pencil beam surveys offer the opportunity of exploring the outer Galactic Halo on which very little is known. Their use should be therefore further investigated, beyond what has been done in the pilot study.

2.12.5 Extremely metal-poor stars in nearby galaxies

A new exciting topic of research, which has emerged in the last few years, is the study the extremely metal-poor populations in nearby galaxies. Such a study should allow to compare the properties of the first stars in different environments. Where the same kind objects formed in deep potential wells, such as our Galaxy, and in dwarf galaxies ? and if they were, was the process of chemical enrichment similar ? The measurement of detailed abundances in the extremely metal poor stars of nearby galaxies could allow to answer these questions. We now know that there exist stars of extremely low metallicity at least in Draco, Sextans and Sagittarius, although we know very little the distribution of stars at these very low metallicity and so far very few stars have been analyzed carefully with high resolution spectra. On this topic almost everything still needs to be done, since it is at its very beginning.

2.12.6 Other topics

This section is put here just as a reminder that a project with a time base of four years must keep the pace of concurrent on-going research. It may well be that topics which today appear not so important in two years time will instead appear at the highest priority. Likewise it is possible that new kinds of investigations, which we cannot imagine now, will become possible and worth pursuing. Therefore the project must not be closed, but open to the new information, both theoretical and observational, which will become available during its progress.

3 Observatoire de Paris, the hosting institution

3.1 General Presentation

The Observatoire de Paris, is one of the principal centres of the French Ministry of higher education and research. It counts on about one thousand employees, of which about 750 with permanent positions. This makes the Observatoire the largest astronomy centre in France and one of the largest in the world. The research covers all the main topics in astronomy and astrophysics, including: metrology of space and time, Sun and Sun-Earth system, planetary systems, interstellar medium, stellar physics of galaxies, cosmology, compact objects and gravitational waves, history of sciences.

Logistically the Observatoire has three sites, Paris, Meudon and Nançay, and is organized in seven Laboratories, four common services and one formation and teaching unit. It is remarkable that within the same institute work, theoreticians, observers, instrumentalists who cover essentially all the expertise in fore-front astronomical research. The Observatoire represents one of the largest concentrations of astronomical knowledge in the world and probably the largest in Europe. The astronomers of the Observatoire are often at the forefront on all topics of astrophysical research. Because of this, the Observatoire is central for European astrophysical research, thus attracting visitors for long and short term visits from all over the world. Researchers operating at the Observatoire have the opportunity of learning the latest developments in astronomy directly from the people responsible for these developments, who, very often pay a visit to the Observatoire to discuss their results with the local astronomers. This makes the Observatoire a unique scientific environment where the most advanced ideas can come together and be enhanced by cross-fertilization.

The Observatoire de Paris is also a University and offers PhD programmes. In this respect the CIFIST team has already started a useful collaboration with the Ecole Doctorale, with one PhD student to start next October under the supervision of one of the team members. One or two more PhD students to start next year with the supervision or co-supervision of CIFIST team members are possible and desirable.

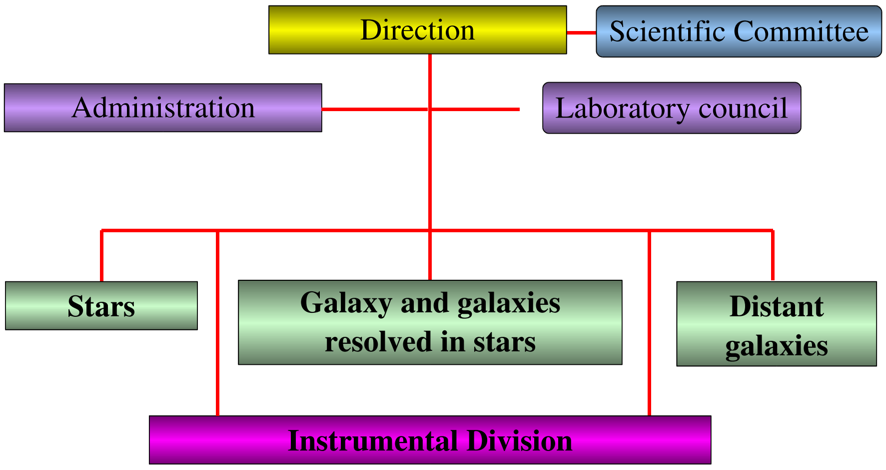

Figure 11: The structure of GEPI.

3.2 The GEPI laboratory

The "Laboratoire d'Etudes des Galaxies et des Etoiles, de la Physique á l'Instrumentation" (GEPI), is the laboratory of the Observatoire which will host the CIFIST team. It was founded in January 2002 and is one of the seven laboratories in which the Observatoire de Paris is organized. As of September 2005 its staff consists of 83 permanent positions (34 researchers, 49 engineers/technical/administrative staff) 7 non permanent researchers and 8 PhD students, for a total of 117 members.

The members of the laboratory perform studies of the Universe from nearby stars to the first epochs, covering all aspects of this study from instrumental concept to data analyses and modelling. Currently on-going researches include:

- Hot and giant stars: envelopes, dust and gas
- Primordial stars: formation of our Galaxy
- Structure of the Galaxy: kinematics and dynamics
- Formation history of galaxies resolved in stars
- Chemistry and dynamics of distant galaxies
- Galaxy formation and cosmology

There is a strong complementarity among several of the above research topics. For example on the one hand there is a group which performs "fossil" studies, i.e. the chemical composition of primordial stars in the Halo (13×10^9 years old) and on the other hand a group which performs "direct" studies, i.e. the chemical composition of gaseous phases of galaxies, more than 8×10^9 years ago.

GEPI is committed to several large projects:

- Major involvement on the Very Large Telescope :
  - Massive data handling and analyses: 150 nights VLT within the 3 last years

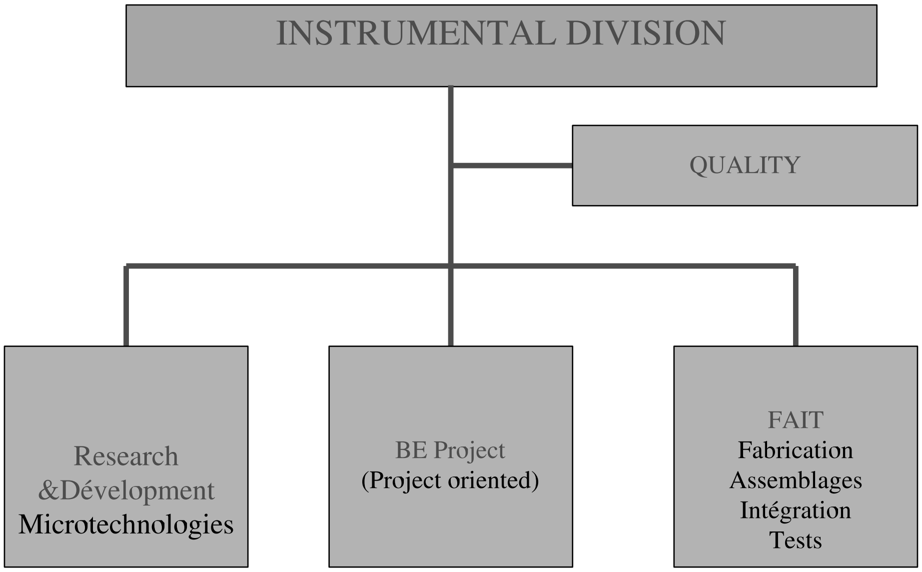

Figure 12: The structure of the Instrumental Division of GEPI.

  - Concept and manufacturing of large instruments: GIRAFFE and X-SHOOTER
- GAIA, a new vision of our Galaxy dynamics:
  - Simulations, concept, data flow (1 billion stars)
  - Concept and follow-up of the radial velocity spectrometer (RVS)
- Increasing involvements in ELT-DS and SKA-DS
  - FALCON/ELT-DS+MOMFIS/OWL, SKA-DS with Nancay
- Data bases and large image analyses:
  - Hipparcos, DENIS, KLUN+, GIRAFFE/UVES + Virtual Observatory

To handle this rather complex array of projects GEPI is organized through functional groups which have well defined interfaces and communication channels. The scheme of the organisation is depicted in Fig. 11.

The Instrumental Division, who is in charge for the concept, manufacturing and management of large instrumental projects VLT(GIRAFFE, X-SHOOTER, FALCON), ELT(MOMFIS), GAIA (RVS) and includes about 30 engineers and technicians is itself organized as depicted in Fig.12.

The Cosmic Impact of the First Stars is one of the hottest topics at GEPI. CIFIST can have a serious impact for all the teams at GEPI. With respect to the CIFIST team, GEPI will support their setting up (administrative and software supports) and collaborate for scientific seminars and meetings. In general GEPI will benefit of the CIFIST members expertise for European large projects such as GAIA, ELT, SKA & AVO.

3.3 Administrative Support

The Administrative staff of the GEPI will support the activities of the CIFIST team. The budget of the team has two main chapters: expenses for the personnel (salaries plus allowances) and expenses for the scientific activity of the team (equipment, missions, consumables).

The expenses will have to be made respecting the recommendations of the European Commission and also the administrative and accounting rules of the French administration.

As far as the personnel is concerned the level of salaries is fixed by the European Commssion, the charges (*charges patronales et salariales*) are fixed by the French legislation.

As far as equipment is concerned, this will be mainly computer equipment. The computer contracts (marchés informatiques) notified and detained by the Observatoire are applicable for all expenses greater or equal to 1€, and are based on the principle of several contractors in competition with each other.

It may also be necessary to acquire material which is beyond the scope of the contracts (*hors de marché*). In this case the procedures are different depending on the amount to be spent. There are five cases: 1) amount less than 4000 €; 2) amount between 4000€ and 15000€; 3) amount between 15000€ and 90000€; 4) amount between 90000€ and 150000€; 5) amount larger than 150000€.

As far as missions and functioning are concerned the rules of French public accounting are applicable.

It may be necessary to modify the budget by shifting money from one chapter to the other. In this case the changes shall be discussed with the Commission services.

The annual budget and the final budget shall be established by the Observatoire and validated by the accounting officer of the French Budget Ministery delgated at the Observatoire, who will also provide audit certificates.

The team will also be able to count on the support from the Unit for International Affairs (*cellule Relationes Internationales*) of the Observatoire.

3.4 Computing facilities at Observatoire de Paris

The Computing Centre of the Observatoire de Paris (Service Informatique de l'Observatoire, SIO) takes care of the network connectivity internal and external, especially of the e-mail services (user accounts, sending and receiving agents) and related security issues.

In addition it maintains several computers for user applications.

- Computers for the data reduction
  - An ES40 quadri processor Alpha EV68 25 Gb, on which are installed the astronomical data reduction software (MIDAS and IRAF).
  - A Linux bi-processor, which is essentially dedicated to IDL users.
  - A Linux bi-processor which is dedicated to the reduction of VLT data
  - A quadri-opteron, on which various astronomical application software packages are installed (MIDAS, IRAF, IRAM, Gildas)
- Computers for the modelisation and numerical computation
  - Computer cluster mesioc (obsolete), consisting on one front-end computer (Dec Alphaserver 1000 – EV5) and several computers used in batch

MPOPM

Parallel computer with shared memory

HP-MARVEL
16 processors alpha EV7 1.15 GHz
memory : 64 Gb

hard disk : 2 Tb

Tru64

work team

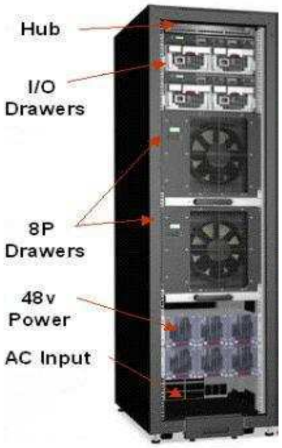

Figure 13: The MPOPM parallel machine.

- Computer mesiop, which is dedicated essentially to the use of Mathematica
- The parallel computer MPOPM, which is a cluster of four quadri-opteron with shared memory.
- An opteron cluster, constituted by one bi-opteron, acting as a front-end and four quadri-opterons, each with 16Gb of RAM memory.

On the MPOPM parallel machine are available parallel libraries MPI and OpenMP, a batch manager (OpenPBS) and the mathematical libraries cxml and scalapack. Computational projects for the parallel machines have to be submitted to a steering committee, which is in charge of the time allocation for the different projects. Currently there are twenty projects which have access to MPOPM and they are numerical simulations which fall in one of the following domains:

1. cosmic structure formation
2. chemistry of complex systems
3. multidimensional radiation hydrodynamics

4 Computing needs

The computing needs of the team fall essentially into four categories:

1. reduction of astronomical data;
2. spectral analysis (line fitting, equivalent width analysis...);
3. computation of 1D model atmospheres and emerging spectra;
4. computation of 3D model atmospheres and emerging spectra.

Tasks 1) and 3) can normally be performed on a normal workstation of medium performance, any off-the-shelf PC with a CPU clock of 3GHz and 1 or 2 Gb of RAM memory are sufficient. This is the case also for task 2), as long as the number of the analyzed stars is less than about 100, analysis of substantially larger number of stars (e.g. analysis of SDSS and SEGUE spectra) can demand the use of more powerful or parallel computers. Task 4) will certainly the computationally more demanding one, experiments with existing codes will be made on both the parallel machines available at Meudon and the perspective is to buy a dedicated machine for these computations. Final decisions on the machine(s) to buy for this purpose shall be taken after extensive experimentation of what is currently available.

It must be considered that the team will require substantial amounts of disc space, which prompts for the use of a storage system. A large disc space is needed for storing the 3D models, which have, of course also a time evolution. Also the treatment of large data sets like SDSS, demands the availability of large disc space. Our estimate is that the minimum disc space to consider is 1Tb, in order to be able to follow the project throughout its duration we consider it is prudent to foresee a space four times larger.

When dealing with such large storage spaces the data safety is of crucial importance. Backup systems based on magnetic tapes do not appear to be suitable. The technical solution which currently seems both cheapest and most efficient is the creation of a mirror system of the storage, which periodically synchronizes its discs with the storage and always contains a backup of the data. This possibility will be actively explored, although possible alternatives will be taken into account.

Each of the team members and of the PhD students needs a desktop computer as a normal "working place"

The immediate needs of the team in terms of computing can be summarized as follows:

1. three desktop computers with a medium class processor, 2Gb of RAM and at least 200Gb of disk space, to be used by Bonifacio, González Hernández and by the PhD student
2. one more powerful computer, with a bi-processor dual core CPU, 4Gb of RAM and 500Gb of disc space, to be used by Ludwig for the development of the 3D codes, it is important to be able to perform on the development machine test and debugging runs, before submitting the computation to a parallel machine
3. a storage system with a desired capacity of 4Tb, but in no case less than 1 Tb
4. a mirror system to be used as backup of the storage system
5. a parallel machine for the computation of 3D models

Items 1) and 2) will be acquired in the shortest possible technical time in order to provide the researchers with a working place. Items 3) to 5) will be the object of an in depth study in order to find the best possible solutions within the available budget and a decision on this shall be taken within the next six months.

5 Logistics

The CIFIST team will be situated at the site of Meudon in building Copernic, block B. At the moment there are three offices available, but by next January all the researchers in that block belonging to the LESIA laboratory will move to a new location and all of block B of Copernic will be given to GEPI. This means that the new researchers which will be hired next year will be accommodated there and also some of the GEPI members who will more closely work together with CIFIST, and are currently in building Hipparque, will be able to relocate to Copernic.

The CIFIST team will finally be formed by 5 researchers, there is already one PhD student, supervised by a team member, who will start in October, one or two more PhD students to start next year are possible and desirable. So one should take into account that CIFIST + PhD students should be in the range 6 to 8 people. It appears that the space in Copernic B is adequate to host this number of students. In addition one should take into account that the team should be able to host visitors. Also in this respect the spaces in Copernic B appear adequate.

It is necessary to foresee a room, to be adequately air-conditioned, where the parallel machine and the storage system, as well as the currently used server dasgal2, and any other server-type machine should prove to be necessary to acquire, can be placed. In Copernic B there is a small room, too small to be used as office, which may serve the purpose, but it has to be suitably air-conditioned.

Required common spaces are a kitchen, in fact existing in Copernic B and a meeting room, which is in fact in the neighbouring block Copernic A and appears suitable for the team internal meetings.

Although the spaces in Copernic B are adequate what is not adequate is the ethernet network and the electric system. Both will have to be upgraded and we foresee the upgrading will take place in January 2006 when the researchers of the LESIA move out of the building. In particular at present each room has a single ethernet socket, considering that each researcher has usually a desktop computer as well as a laptop computer it should be foreseen to place 4 ethernet sockets in each office, in order to allow to place two researchers in some offices. In addition an adequate number of sockets should be present in the computer room, and this latter should be connected directly to the Gigabit line which arrives at Copernic. Two or three sockets should be also foreseen in the entrance of the block where the printers shall be placed, currently the two printers which are there (belonging to LESIA) are connected through a long cable connecting them to the socket in one of the offices. As far as electrical sockets are concerned there are two per office, this number is clearly insufficient. A desktop computer uses typically two sockets to which you should add a socket for a laptop and one for a table lamp. Therefore 4 electrical sockets per researcher, i.e. 8 per room, conveniently placed, is the requirement. It is also important to provide some stabilization mechanism, at least for the servers (storage system, parallel machine etc...), to prevent as much as possible damage to the equipment due to jumps in the voltage on the electrical network.

6 Early scientific plans

Within the first six months, the team will work on the following topics, planning in the mid-term will depend also on the results of the first six months:

1. analysis of the spectra of Turn-Off stars from the First Stars project with 1D and existing 3D model atmospheres;
2. improvement over existing 3D atmospheres by inclusion of more complete opacities;
3. analysis of the existing spectra of binary TO stars of extremely low metallicity;
4. Analysis of existing spectra of stars of extremely low metallicity in the Sgr dSph galaxy;
5. feasibility study for the exploitation of SDSS spectra;
6. analysis of the existing data of the pencil beam survey of the Chandra Deep Field South.

In August 2006 the General Assembly of the International Astronomical Union will take place in Prague. This will be an excellent opportunity to present the early results of the CIFIST team. At least one of the Symposia and three of the Joint Discussions are of interest of the team members. Plans will be made as early as possible for the attendance of all three the present team members to the IAU GA, each member shall present at least one contribution to a IAU Symposium or a JD.

Other conferences if interest of the team members in 2006 will be considered.

7 Immediate Actions

At the end of the meeting I have assigned the actions listed in table 1 to the team members and GEPI collaborators.

Table 1: Immediate Actions to be carried out by the CIFIST team.

Action	People	Timescale
buy desktop computers	Bonifacio, Ludwig	1 month
arrange upgrade of ethernet network	Bonifacio	2 months
arrange upgrade of electrical network	Bonifacio	2 months
chose parallel machine, storage system & backup	Ludwig, Cayrel	6 months
write proposals for new observations at ESO and TNG	Bonifacio	1 month
port 3D codes to MPOPM and verify efficiency	Ludwig	4 months
verify available data on binary stars	González Hernández	3 months
explore use of existing SDSS data	Ludwig, Bonifacio	3 months
analysis of TO stars from First Stars	Bonifacio, Ludwig, González Hernández	6 months

A Kick-Off Meeting Programme

CIFIST Kick-off meeting September 8th 2005

Opening session (Chairman R. Cayrel)

9:00
Welcome address, the CIFIST host institution D. Egret

9:15
The CIFIST team goals and means P. Bonifacio

9:30
The interaction with the GEPI department F. Hammer

9:45
The interaction with the EC N. Deliyanakis

10:00
Admimistrative support for the team J. Pluet

10:15
European Projects at the Observatoire de Paris C. Adam

10:30
Computing Facilities at Observatoire de Paris P. Le Sidaner

10:45
Coffe Break

Morning Scientific session (Chairman P. Molaro)

11:15
The First Stars project and its interaction with CIFIST R. Cayrel

11:45
Current Status of 3D model atmospheres, available models and codes. Immediate actions H. Ludwig

12:15
Chemical composition of secondary stars in LMXBs: implications on the progenitors of black holes and neutron stars. J. González-Hernandez

12:30
Lithium in metal-poor stars F. Spite

12:45
CNO in metal-poor stars M. Spite

13:00
Heavy elements in metal-poor and Globular Cluster stars P. Francois

13:30
Lunch

Afternoon Scientific session (Chairman F. Spite)

14:30
Search for r-enhanced stars in our Galaxy and primordial populations in external galaxies V. Hill

14:45
Codex: high resolution spectroscopy for the 100m telescope P. Molaro

15:00
GAIA spectroscopy C. Turon

15:15
Round table: Logistics moderator M. Spite

16:15
coffe break

16:45
Round table: early scientific plans moderator: P. Bonifacio

17:45
Actions to be taken P. Bonifacio

B Kick-Off Meeting Participants

- C. Adam (Observatoire de Paris, Office of International Affairs)
- C. Balkowski (Observatoire de Paris, GEPI)
- C. Bentolila (Observatoire de Paris, GEPI)
- J. Borsenberger (Observatoire de Paris, GEPI)
- P. Bonifacio (CIFIST team, Observatoire de Paris)
- M. Celermajer (Observatoire de Paris, General Secretary)

- G. Cayrel (Observatoire de Paris, GEPI)
- R. Cayrel (Observatoire de Paris, GEPI)
- N. Deliyanakis (European Commission,Marie Curie actions, Promotion of Scientific Excellence)
- D. Egret (Observatoire de Paris, President)
- P. François (Observatoire de Paris, GEPI)
- A. Gómez (Observatoire de Paris, GEPI)
- J. González-Hernandez (CIFIST team, Observatoire de Paris)
- F. Hammer (Observatoire de Paris, director of GEPI)
- V. Hill (Observatoire de Paris, GEPI)
- H. Ludwig (CIFIST team, Observatoire de Paris)
- P. Le Sidaner (Observatoire de Paris, SIO)
- P. Molaro (INAF-Osservatorio Astronomico di Trieste)
- J. Pluet (Observatoire de Paris, GEPI)
- C. Stehlé (Observatoire de Paris, vice-President)
- C. Turon (Observatoire de Paris, GEPI)
- F. Spite (Observatoire de Paris, GEPI)
- M. Spite (Observatoire de Paris, GEPI)
- C. Zeippen (Observatoire de Paris, vice-President)