INSTITUTO DE ASTROFÍSICA DE CANARIAS

GRADUATE STUDIES DIVISION

THESIS PROJECT PROPOSAL FORM

NAME OF THE PROPONENT:

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TITLE OF THE THESIS PROJECT:

Search and characterization of galaxies with the lowest metallicity

Búsqueda y caracterización de las galaxias con mas baja metalicidad

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SUMMARY:

The nearby dwarf galaxies of lowest metallicities are probably unevolved fossils from the early universe and, consequently, they provide unique information to understand structure formation, and to constraint cosmology. Unfortunately, they are extremely scarce and, therefore, poorly known. The thesis work has three aims. First, enlarging the list of these extremely metal-poor galaxies by looking them up in databases (SDSS). Second, a representative sample of these targets will be observed using large telescopes, preferentially the GCT. Third, these galaxies will be characterized, paying particular attention to the metallicity of both the gas and the stellar content. The thesis work should be able to figure out if all (nearby) galaxies were created with a minimum metallicity, and to determine its value.

SHORT LIST OF OBJECTIVES:

1. Search the SDSS database for nearby galaxies with the lowest metallicities.
2. Use this information (plus the scarce data in the literature) to select a representative set of the most metal-poor galaxies in the nearby universe.
3. Whenever needed, confirm the low average metallicity of those galaxies using WHT spectroscopy.
4. Use GTC to observe this sample. Derive primary parameters (e.g., magnitudes and colors), and secondary parameters (e.g., masses and star-formation-rates).
5. Among the secondary parameters, pay particular attention to the metallicity. It will be derived for various metals, and both for the ionized gas and the stellar content.
6. Answer three specific questions: What is the minimum metallicity among the galaxies in the local universe? Is there a minimum galactic metallicity? Why is the lowest galactic metallicity so high as compared to (some) halo stars in our galaxy?

NATURE OF THE THESIS WORK: (Please describe the nature of the work to be carried out -observational, theoretical, on instrumentation, etc.-, as well as the ways to stimulate the student's general skills, creativity and Physics learning in this field)

The work is observational in nature, with the primary goal of analyzing new observations. However, carrying out the work will force the student to become familiar with most of the techniques used in modern extra-galactic astronomy. The student will have to search large databases for targets. He/she will have to write observing proposals, and to observe and reduce data from major astronomical facilities. Photometry and spectroscopy will be used as tools, and the observations will have to be interpreted using theoretical models (e.g., population synthesis models to estimate stellar ages and metallicities). If the student becomes proficient in all these fields, a future in professional astronomy is guaranteed. Learning how to deal with all this techniques and tools may sound a bit too much for a PhD student, however, the thesis will be developed in a large group with world-wide experts in every aspect of the work, and they are willing to help. Skillful hardworking students will find the environment exciting and supportive.

Creativity is very hard to stimulate and extremely easy to suffocate by the competitive atmosphere of professional research, where quantity often prevails over quality. The proponents are proud of appreciating the value of imagination in science, and they will do their best to preseve the natural student's creativity.

DETAILED DESCRIPTION OF THE THESIS PROJECT: (Please include an estimate of the amount of time necessary for each phase of the project. Use a maximum of three pages)

Scientific Rationale. The nearby dwarf galaxies of lowest metallicities are probably unevolved fossils from the early universe and, consequently, they provide unique information. Studies of their nearly pristine interstellar medium (ISM) can shed light on the properties of the primordial ISM at the time of galaxy formation. Even the most metal-deficient galaxies in the local universe formed from matter that was already preenriched by a previous star formation episode, and the determination of the minimum galactic metallicity seems to be the best constraint available on the first stars (Thuan & Izotov 2005). Because they have not undergone much chemical evolution, these galaxies are also the best objects for the determination of the primordial He abundance that constrains cosmological models. In the hierarchical picture of galaxy formation, large galaxies form through the assembly of small dwarf galaxies (e.g., Diemand et al. 2007). While much progress has been made in finding large populations of galaxies at high redshift, truly young galaxies in the process of forming remain elusive in the distant universe. Extremely metal-deficient dwarf galaxies are possibly the closest examples we can find of the elementary primordial units from which galaxies formed. The study of nearby objects of extremely low metallicity allows detailled studies that are impossible in distant high-redshift galaxies.

Blue Compact Dwarf (BCD) galaxies (Caon et al. 2005; Amorín et al. 2007, and references therein) are the galaxies with the lowest known metallicity and, therefore, they are the most promising young-galaxy candidates in the local universe (e.g., Kunth & Östlin 2000). Unfortunately, extremely metal-deficient BCD galaxies are rare. For decades I Zw 18 held the record of lowest metallicity (Sargent & Searle 1970), and although a few other examples have been recently found (e.g., Izotov et al. 2005), there seems to be a minimum metallicity close to that of I Zw 18, and corresponding to one hundredth of the solar value (e.g. Kunth & Östlin 2000). Because of their scarcity and the existence of the metallicity threshold, the extremely metal-poor BCDs seem to be unevolved objects constraining the properties of the early universe.

The thesis work aims at characterizing a statistical significant sample of those objects. As we point out above, extremely metal-poor BCDs are rare, and the smallness of the sample represents the bottleneck of the thesis project. Fortunately, our group has available a significant number of new targets found as a by-product of a different study on BCD evolution. We compiled from SDSS/DR6 a long list of 1609 BCDs galaxies (Sánchez Almeida et al. 2008). This list contains a handful of metal-poor BCD candidates which, together with the targets existing in the literature, will allow us to select an homogeneous set of about 20 BCDs to carry out the study.

Specific Work, instrumentation and timescales. The thesis work will have four phases, each one of which is expected to last one year. The first year is not researchwise demanding, because the student is expected to devote a significant part of his/her time attending PhD courses.

Year 1.- Selection of the final sample of metal-poor BCDs. This phase involves confirming the (low-)metallicity of those candidates for which SDSS spectra may be insufficient. WHT additional time to prepare GCT proposals will be used.

Year 2.- GCT observing time application and observation. The group is involved in a GCT-consolider proposal and an ESO-GCT proposal, which will include some of the targets. Therefore, there are reasonable changes of getting observing time this year. We will also submit ESO-VLT proposals and, to start with, the traditional metal-poor BCDs are well studied and, therefore, excellent archive data are available for them. Reducing these data will require a full working year.

Year 3.- The observational properties of the extremely metal-poor BCDs have to be determined – magnitudes, colors, sizes, equivalent widths of lines, etc. Quantities like masses, starformation rates, extinctions, etc. will be inferred from them. The properties to be derived refer to both the BCD itself, as well as the BCD host galaxy present in some BCDs.

The metallicity estimate is the central part of the analysis and special care will be taken. We expect to be able to separate both the H II gas metallicity, and that of the underlying stellar component. Follow-up spectroscopy would be requested and analyzed if needed.

Year 4.- Thesis writing and defense. Try to answer three specific questions: Is there a minimum galactic metallicity? What is the minimum metallicity among the galaxies in the local universe? Why is this metallicity so high as compared to the stars in the halo of our galaxy (e.g. Christlieb et al. 2002).

Make the data set publicably available (whether totally or partially remains TBD).

Our proposal is ambitious and, if fully completed, it would be of mayor impact, leaving a unique set of observations of the most primitive galaxies in the nearby universe. However, we are down-to-earth, and the sample of 20 BCDs may not be completed by the time that the thesis needs to be submitted. We want to emphasize that even completing a fraction of the project would be a mayor leap on the field. Moreover, the training of the student will not suffer. From the first BCD on, he/she will be exposed to all techniques and tools required to complete the task.

PREVIOUS EXPERIENCE OF THE PROPONENT IN THE TOPIC:

The IAC starburst group lead by one of us (CMT) has an ample experience both in extragalactic astronomy, and in supervising PhD students. It is extremely well considered by funding agencies because of its size and sinergies with other groups. Details of the group, research and publications can be found in the group webpage,

`http://www.iac.es/proyecto/GEFE/portal.html`

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