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NANOCOSMOS: a trip to the nanoworld

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Abstract

Cosmic dust is made in evolved stars. However, the processes involved in the formation and evolution of dust remain unknown so far. The project "Gas and dust from stars to the laboratory: exploring the NANOCOSMOS", takes advantage of the new observational capabilities (increased angular resolution) of the Atacama Large Millimeter/submillimeter Array (ALMA) to unveil the physical and chemical conditions in the dust formation zone of evolved stars. These observations, in combination with novel top-level ultra-high vacuum experiments and astrophysical modelling, will provide a cutting-edge view of cosmic dust. The importance of publishing scientific results based on NANOCOSMOS in the scientific literature goes without saying. But it is also important and a stated NANOCOSMOS objective to disseminate the achievements of the project and its scientific and technological results to a wider audience. In this presentation we will discuss the tools used to spread them to the society. This presentation is structured as follows: 1. What is Astrochemistry?; 2. What is NANOCOSMOS?; 3. Outreach in the NANOCOSMOS programme; 4. Conclusions.

1 Introduction

In NANOCOSMOS scientists from diverse areas work together with a common goal: the understanding of the molecular universe. Molecules play a fundamental role in the evolution of the universe, its abundance and variety, and in the evolution of life by its richness in organic matter. For this reason, we talk about a Molecular Universe. Experts in laboratory spectroscopy, chemists, molecular physicists and astronomers have teamed up to study, with an innovative approach, these molecules found in space, trying to elucidate, not only which species are in each area, but also the implications they have on the physical and chemical processes that govern the universe.

2 What is Astrochemistry?

Dust and gas are at the beginning and at the end of every process of change in the Universe. Cosmic dust grains are probably triggering most of the gas molecules interactions, as they play an important role hosting those molecules and, probably, providing them with the necessary conditions to mix and to protect them against photodissociation.

We began to know about these interactions in the 60s of the past century. New instruments, in particular radiotelescopes, allowed us to discover that there is a lot of Chemistry in space. And this is how Astrochemistry was born.

Then, this new science began to discover the presence of molecules unexpected in space and to explain some of their behaviors.

Astronomers detect molecules in the space between stars, the interstellar medium, both in diffuse and high density molecular clouds, but also in more extreme environments: supernova explosions and the gas around black holes. They try to understand how these molecules can survive in these harsh environments and what they can learn from them.

Astrochemists can answer nowadays many questions related to chemical abundances, complex molecules in space and surprising features of the different environments that allow gas molecules to survive and interact.

Tiny dust grains, together with atoms and molecules, injected into the interstellar medium, play a key role in the evolution of astronomical objects, from galaxies to the embryos of planets.

But there is a gap, an unknown part of the story they want to uncover: how do the dust grains originate?

Cosmic dust plays an important role in the chemical evolution of the universe. The aim of the **NANOCOSMOS** project is to understand the physical and chemical processes leading to the formation of dust grains in space and to study the evolution of these dust grains when under different physical conditions.

Dust grains are responsible for the formation of complex organic molecules in interstellar clouds; the ices that are formed on the surface of these dust grains permit to increase the chemical complexity and the study of the formation of these dust grains is an important topic in astrophysics.

Unfortunately, with observations and modelling it is not possible to understand all the physical and chemical steps that produce these dust grains and this is why we need experiments from the laboratory.

3 What is NANOCOSMOS?

NANOCOSMOS will be several devices that will permit to study the physical and chemical processes that occur in the photosphere of evolved stars and to study how dust grains are formed, how these grains interact between them and with the gas to produce the grow of these particles (these nanoparticles) until the final step of dust grains that are ejected to the

Figure 1: NANOCOSMOS logo.

interstellar medium.

The proposed approach presents many technological challenges: recording the spectroscopy of key molecular species involved in dust formation, studying the chemical and physical properties of tiny (nano)grains in fully controlled laboratory conditions that will mimic these astronomical environments.

The NANOCOSMOS project goals are:

- Star death is the beginning of stardust
- Beyond the current frontiers
- First ALMA observations
- Experimental set-up development
- The interdisciplinary team

The Coordinator of the project is José Cernicharo (Instituto de Ciencia de Materiales de Madrid, Consejo Superior de Investigaciones científicas (ICMM-CSIC), Spain. The PIs (Principal Investigators) are José Cernicharo, from ICMM-CSIC, Christine Joblin, from Institut de Recherche en Astrophysique et Planétologie - Université de Toulouse (UPS) & CNRS (France), and José Ángel Martín-Gago (ICMM-CSIC).

4 Outreach in the NANOCOSMOS project

Outreach is not a choice. It is the commitment of the scientific community and it is a **Human Right** [1]: First internationally recognized in the Universal Declaration of Human Rights (1948), the **right to enjoy the benefits of scientific progress** is enshrined in Article 15 of the International Covenant on Economic, Social and Cultural Rights (1966) (ICESCR) (7). Addressing science through a human rights lens is both novel and potentially significant.

Science policy guided by human rights principles may set priorities and allocate resources differently from policies driven by commercial interests, the interests of scientists, or national scientific competitiveness. Furthermore, addressing science through a human rights lens offers the potential to identify universal standards and norms that can facilitate harmonizing global science.

Since 1966 four core components strengthen this Human Right [2]:

i) access by everyone, without discrimination, to the benefits of science and its applications, **including scientific knowledge**;

ii) opportunities for all to contribute to the scientific enterprise and the freedom indispensable for scientific research;

iii) participation of individuals and communities in decision-making about science and the related right to information; and

iv) development of an enabling environment fostering the conservation, development, and diffusion of science and technology (S&T).

The importance of **publishing scientific results** based on NANOCOSMOS in the **scientific literature** goes without saying. But it is also important **and a stated NANOCOSMOS objective to disseminate the achievements of NANOCOSMOS and its scientific and technological results to a wider audience**.

Of course, scientific, technical, business, institutional and governmental audiences are all prime targets. But, because NANOCOSMOS is supported by public funds, there is an equal responsibility to show citizens that money is being spent to good effect. Fulfilling the societal objectives of spreading education and generating an enthusiasm for science also implies a need to reach the public at large, using all available means. In order to do this, it is important to create win-win situations for NANOCOSMOS scientists, their institutes, national organisations, funding agencies, mass media and general public.

The World Wide Web has become a major information channel. This success is explained by the variety and multitude of information it makes available to a wide number of people at any time with a few clicks of a mouse. This is why the most common form of science communications proposed is by means of writing, posting, and widely disseminating web news and releases based on scientific results.

The news come in two flavours, one aimed at the special interest community, posted on a specific **NANOCOSMOS SciTech portal** (http://www.icmm.csic.es/nanocosmos/), and another intended for the media and the general public posted on an **Outreach Portal** (http://www.icmm.csic.es/astromol/).

Both are key tools to raise the image of the project and improve dissemination to specialists, potential users of the technologies being developed, politicians and public funding authorities, as well as the general public.

The **Outreach portal** hosts the news and press releases, focused depending on the subject: science-release, techno-release, hotnews, photo-release, etc.

Social accounts were created in facebook, twitter and Google+ to spread all the news and information generated in the website. Fully-fledged press conferences can be considered, but are reserved for exceptional circumstances.

NANOCOSMOS will have a "Communication team", composed by the Manager and a Public Information Officer (PIO). They will be the contact points for the NANOCOSMOS community to spread all the information created by the project teams. Once the scientist/engineer has a NANOCOSMOS result or considers any advance interesting to a wider audience, the team, through the Principal Investigator (PI), should bring this to the Communication team attention that will be in charge of developing the information. The interaction can mainly be by email.

5 Conclusions

Communicating and disseminating the science and technology developed by the research projects should aim to demonstrate the ways in they are contributing to our everyday lives by creating jobs, introducing novel technologies, or making our lives more comfortable in other ways. But one of the things we usually forget is the importance of all the **KNOWLEDGE** generated during the scientific and technological process. This is also something to give back to society, because "The social contract is not complete until the results are communicated" [3].

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