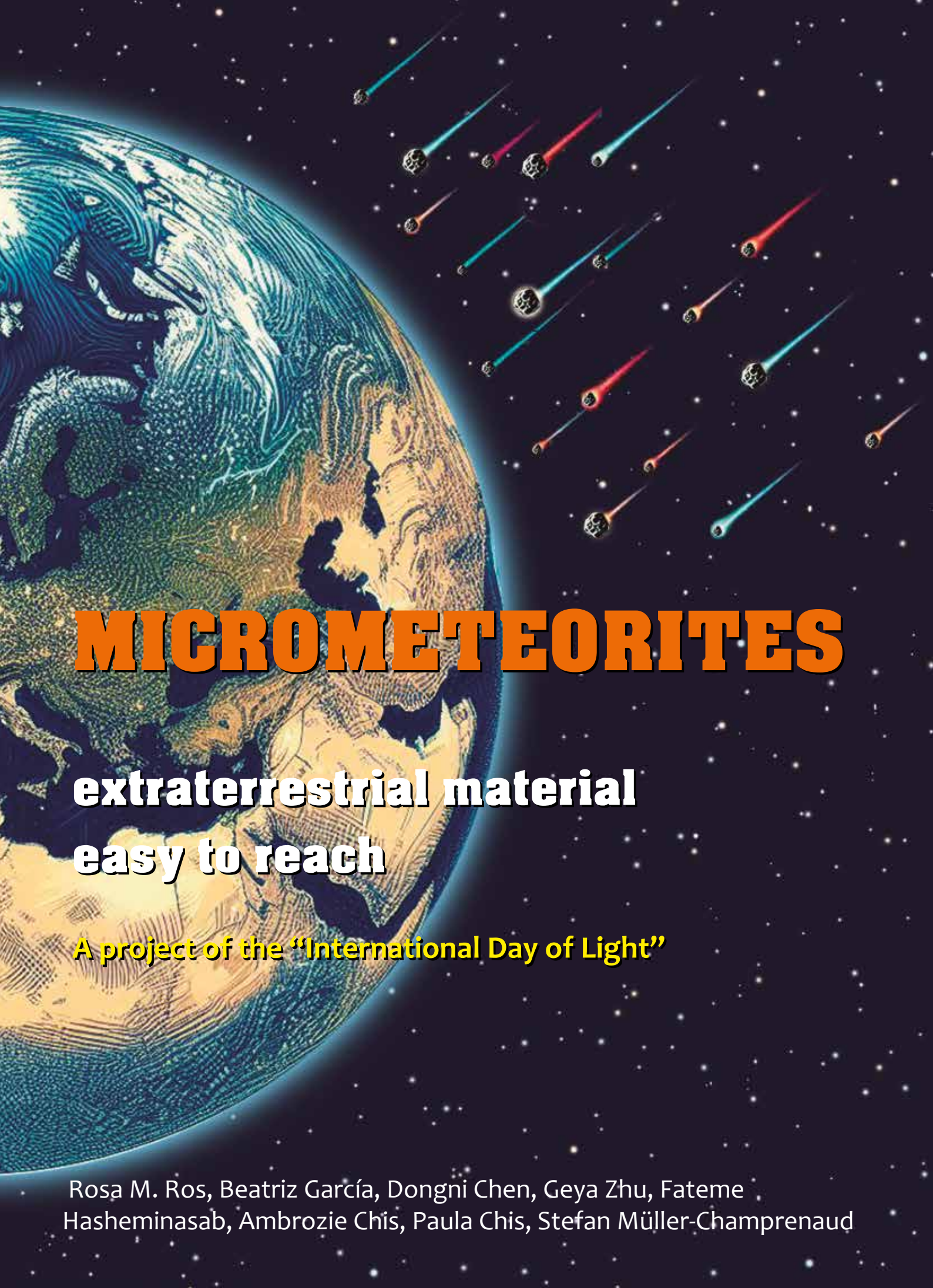


MICROMETEORITES

extraterrestrial material easy to reach

A project of the "International Day of Light"

Rosa M. Ros, Beatriz García, Dongni Chen, Geya Zhu, Fateme Hasheminasab, Ambrozie Chis, Paula Chis, Stefan Müller-Champrenaud

MICROMETEORITES: extraterrestrial material easy to reach

A project of the "International Day of Light"

Rosa M. Ros

Beatriz García

Dongni Chen, Geya Zhu

Fateme Hasheminasab

Ambrozie Chis, Paula Chis

Stefan Müller-Champrenaud

Credits: Alan C Pickwick – English editor

Authors: Rosa M. Ros, Beatriz García, Dongni Chen, Geya Zhu, Fateme Hasheminasab, Paula Chis, Ambrozie Chis and Stefan Müller-Champrenaud

Editorial: Guillermo Valentín

ISBN: 978-84-09-60170-7

Prologue

From October 27 to 29, 2023, Viladecans hosted, for the fourth time in just 8 years, a new edition of the Science in Action competition. This edition has been special for us because it has been the first contest of the new era of Science in Action since Rosa M. Ros left the direction of this landmark event in 2022. Currently, Science in Action is an event included in the Innpulso Network of the Ministry of Spain, for the Cities of Science and Innovation, made up of more than 100 cities throughout Spain. The technical secretariat is located in Viladecans, which has a great commitment to scientific dissemination, innovation and commitment to international goals in the face of climate change. Two weeks before the Science in Action meeting, Viladecans won the 2025 Green Leaf European city award, where scientific knowledge has played a key role in achieving this European recognition. Science is also behind many of the city projects we are developing, such as the mission to become a carbon neutral city by 2030, the naturalization city plan, among many others.

The desire to be a city that generates opportunities for all its neighbours has made Viladecans turn the promotion of culture, access to technology, innovation in education and the promotion of the city from the social and economic point of view. Projects like Science in Action or the final event of NASE, within UNESCO, fit perfectly with the objectives of Viladecans, where we emphasize educational success, innovation and the promotion of equal opportunities for citizens, a promotion to which education, science and culture are some of the fundamental pillars of the local government team. For this reason, in Viladecans we will continue to pay attention to the future work that you do for the program and we will open the doors of our city for whatever you need.

I hope we meet again in the future and continue to bring the fascination of scientific magic everywhere. Thank you for choosing us to meet again in our city.

Sincerely,

Jordi Mazón

Deputy Major of Promotion and Dissemination of Science

Municipality of Viladecans

The final event of “Science in Action 2023” - that is to say “Science on Stage Spain 2023” took place in Viladecans, near Barcelona, Spain. On this occasion as in previous events, the Great Experience corresponded to a project within NASE and UNESCO's International Day of Light activity for the year. In 2023, teachers and students were invited to look for micrometeorites. This simple activity allows schools to get extraterrestrial material in order to study it with their students. The project was a success and many schools and students in all the world found these materials.

The number of participating countries was 28: Algeria, Argentina, Armenia, Benin, Bulgaria, China, Colombia, Dominican Republic, Ecuador, Ethiopia, Finland, Germany, Greece, Guinea Conakry, India, Iran, Latvia, Mongolia, Nicaragua, Panamá, Paraguay, Portugal, Romania, South Korea, Spain, Uruguay, USA and Vietnam. The people there collected a total of 180 reports carried out by primary and secondary schools, universities and observatories. We increased the number of countries and reports received from previous events.

Twenty international institutions collaborated with this proposal, such as the Cité de la Science en Túnez, Túnez, CLEA, the Comité de Liaison Enseingants et Astronomers, France, the Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina (CONICET), the Consejo Superior de Investigaciones Científicas, España (CSIC), Entoto Observatory, Ethiopian Space Science Society, Ethiopia (ESSTI), the Institut für Astrophysik, University of Wien, Austria, the Institut Teknologi Bandung, Indonesia, Instituto de Astrofísica e Ciências do Espaço, Portugal, Iranian Teacher’s Astronomy Union, Iran (ITAU), the Instituto de Tecnologías en Detección y Astropartículas (ITeDA, CNEA-CONICET-UNSAM), Argentina, the Institut Teknologi Sumatera, Indonesia (ITERA), the Students Iranian Network for Astronomy (SINA), Iran, the National Astronomical Reseach Institute (NARIT), Thailand, the Beijing Planetarium, China, the Planetario de Oporto, Portugal, the Universidad Nacional de Cuyo, Mendoza, Argentina and University of Oporto, Portugal. These institutions disseminated the Project throughout the world, between the equinoxes from March to September. The program concluded with a face-to-face session on October 27th and an online session on October 28th.

Fifteen teachers from Armenia, Bulgaria, Germany, Mongolia, Spain and Romania participated in Viladecans and were organized in groups in six tents in the city of Viladecans, where local students had the opportunity to visit these spaces to learn about micrometeorites.

In particular, we must highlight the great work carried out by the Municipality of Viladecans for collaborating in the organization of the event, the movement of local teachers and their students from the different centres to the points where the demonstrations took place.

Rosa M. Ros Ferré
President of NASE-IAU

Introduction

As in previous events, NASE (Network for Astronomy School Education) designed and executed a project as a Great Science in Action Experience within the scope of the UNESCO “International Day of Light”.

The “Light, Cameras and Life” proposal was developed from March to September 2023 and began with the synchronous online event “3rd Bridges between Cultures” (Ros & García, Eds. 2023)).

As we explained in that event, it is not clear that life began on Earth. It is possible that life began outside our planet and could have arrived through the exchange of rocks thanks to the impact of comets, asteroids or meteorites.

Recently, a new estimation of how much space rock falls to Earth each year (Evatt et al, 2020) proposes a total of 16,000 kilos. That calculation includes only meteorite material above 50 grams in mass. It does not take into account the dust that is continually settling on the planet.

Protected from conditions of outer space, microbes could survive trapped in the rocks and finally evolve to more complex forms of life during millions of years in the good environment of the Earth. Life is made of material processed as part of the evolution of the stars. If it arrives in rocks, we can plan to have a sample of it, in the smaller version that we can have here: the micrometeorites.

The final closing event took place in two ways:

a) a face-to-face event on October 27th in the city of Viladecans (Barcelona, Spain) as a “Great Experience” of the international Science in Action program in order to promote the study of extra-terrestrial material in the school.

b) a hybrid meeting on October 28th with the presence of participants from all over the world.

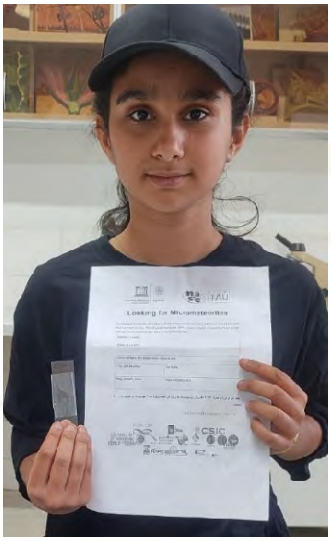
Within the framework of Science in Action and also integrated into the proposals for UNESCO’s “International Day of Light”, NASE has been developing these “Great Street Experience” type projects for the last five years.

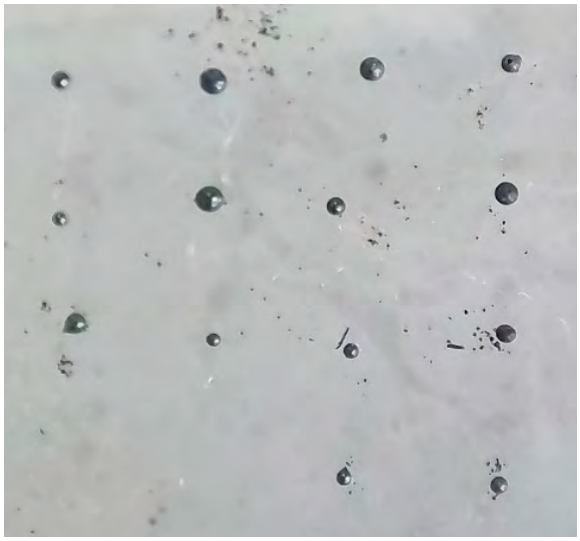
During the active period of the project, teachers and students carried out the experience in their countries, and sent their results schematically, using the form provided by NASE, to assure uniformity in the data acquisition, as can be seen in figures 2a and 2b.

Fig. 1: Group photo of the teachers who participated in the in-person final in Viladecans (Barcelona) together with the councillor for Scientific Promotion and Dissemination of Viladecans and the Mayor of Ermua and other members of the Innpulso Network. (Credit: Jordi Mazón).

Teachers and professors in 80 countries of NASE community have been able to carry out the experience. Some of the professors (figure 1) were in Viladecans with the students of this city, repeating the process and getting many micrometeorites that students took at home.

In this sense, the full cooperation of the Viladecans City Council, which presides over the Innpulso network (of the Ministry of Science and Innovation of the Government of Spain) of city councils interested in the promotion and scientific development of society, was fundamental.





ig. 2a and 2b. Example of a student with her report and her collection of micrometeorites, Iran. student (Credit: Jahangir Bahmani).

1. Micrometeorites

Micrometeorites: How to get extraterrestrial material

It is easy to collect micrometeorites, often suspended in the atmosphere for long periods of time and falling on Earth transported by different types of precipitation (such as rain or snow).

These types of objects come directly from the matter that gave rise to the solar system, and therefore have an age of about 4,500 million years. The surprising thing is that it can be collected in a simple way.

Meteors pass through the exosphere and thermosphere without difficulty because these layers are not very dense. But when they reach the mesosphere, the density is greater and when friction with the air occurs and heat is dissipated, the conditions are given for the material to melt and then solidify again in the stratosphere and troposphere (figure 3), so at the end of the trajectory it presents a spherical shape, sometimes with striations and sometimes small bubbles, as a consequence of the rapid solidification (Ros & Hemenway Eds, 2018).

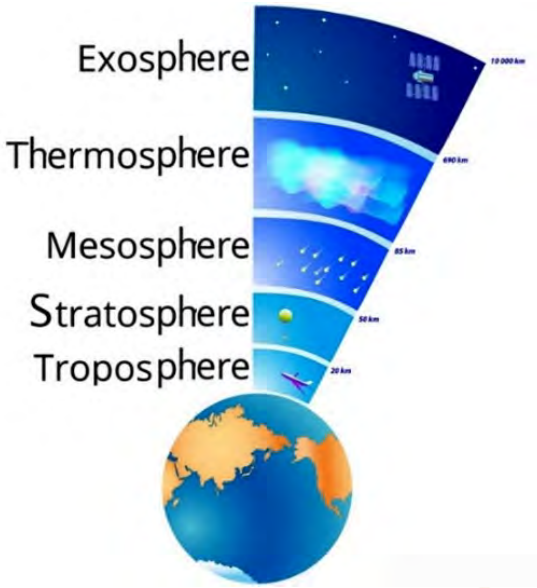


Fig. 3: Terrestrial atmosphere.

Already on the surface of the Earth, those that are made of iron and nickel can be detected, separating them from other objects and rocks on the surface with the help of a magnet. However, in the soil there is a huge amount of ferromagnetic elements that remain trapped on the magnet. These are separated from the rest of the small non-ferrous particles in the collected sample with the help of a fine sieve.

To see the small spheres, a magnifying glass is enough: micrometeorites have a unique characteristic that allows them to be identified: they are spherical!

Simulating Edible Micrometeorites

To simulate (and understand) the way in which these objects arriving from outer space acquire their spherical shape, we propose a very simple experiment.

Fig. 4a: In a “casting effect” saucepan, Fig. 4b: Making the drip with a syringe, Fig. 4c: Column of cooling and condensation to form the spheres (Credit: Paula Chis),

The implements for the activity are in figure 4a. Heat 75 ml of chocolate milkshake or fruit juice in a saucepan and, before it comes to the boil, remove from the heat and add 1 gram of agar-agar and stir well. If agar-agar is not available, replace it with gelatine.

Fill a tall and transparent cylindrical container with very cold sunflower oil as a cooling column. (advice: put the oil in the freezer for at least 30 minutes before using it). With a syringe or pipette, let drops of the heated liquid fall into the column of cold oil (figure 4b). The contrast of temperature and the density of the oil cause small spheres to form immediately. Than we only have to drain the small spheres well (figure 4c).

Looking for Micrometeorites in 3 steps

1) Collection

1st method: Recovery of micrometeorites from material in gutters and road ditches.

The easiest and most recommended method to obtain micrometeorites consists of recovering the material that is continuously deposited on roofs, roads, etc. When it rains, the water washes them away, so a good place to collect micrometeorites is in the gutters on roofs and in the gutters of streets or roads, once they are dry. Simply collect some sand on a sheet of paper that you find in those places (figures 5a and 5b).

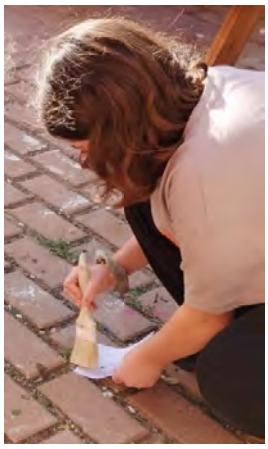


Fig. 5a: In the street you can find gutters or gutters where, after collecting the water, there is sand where we can locate meteorites. Fig. 5b: We collect this grit with a piece of paper and proceed to analyse it (Credit: Ricardo Moreno, Rosa M. Ros).

2nd method: Construction of a general micrometeorite "trap".

You can also build simple "traps". For this you need the following items:

- a kitchen tray
- transparent cellophane paper (kitchen wrap)

Cover the tray with the cellophane by folding the edges or gluing the cellophane underneath to prevent it from blowing away (figures 6a, 6b and 6c).

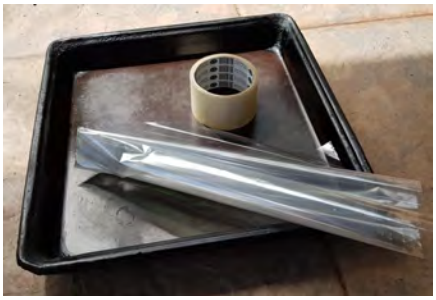


Fig. 6a: Tray, cellophane and tape, Fig. 6b: Micrometeorite "trap" set up in the garden for 2 days, Fig. 6c: Transfer all the material accumulated.

Place the tray slightly off the ground to prevent surrounding dust or the presence of animals from contaminating the sample (figure 6b), in a place where there is not much wind and where nothing blocks the sky.

Leave this setup outdoors for at least two days or a week. The paper will start to look “dirty”. At the end of the time, transfer all the material accumulated on the cellophane or film to a sheet of paper.

3rd method: Building an individual micrometeorite “trap”.

It is possible to prepare an individual trap for each student. It is necessary to have the following items:
• a paper cup
• a string for each cup
• a small magnet

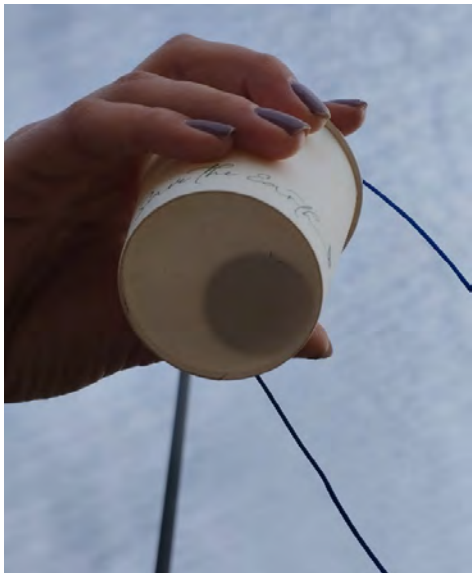


Fig. 7a: The cup tied with a string and a small magnet inside. Fig. 7b: Student using the cup looking for micrometeorites (Credit: Rosa M. Ros).

In order to prepare the trap for each student we tied the cup with a string and we put a small magnet inside the cup (figure 7a). Students move around the schoolyard area with the magnet cups (figure 7b). Then remove the magnet and, if there are iron particles (micrometeorites), they will fall onto the white sheet of paper. Students observe with their phone cameras to find micrometeorites (they are small spheres).

2) Separation and identification.

In the first two cases, gutters or the trap, pass a magnet under the sheet of paper with the material: it will clearly be seen how small particles of ferrous material that are attracted to the magnet (figure 8). Without pulling the magnet away, flip the paper over and all the sand will fall out, except those fine dark particles, which will be attracted to the magnet's magnetic field. Flip the paper over and remove the magnet. There may possibly be micrometeorites there.

Fig. 8: The magnet, under the sheet of paper, drags the ferromagnetic material (Credit: Beatriz García).

When viewing the sample with a magnifying glass or a mobile phone camera at maximum zoom (figure 9), the particles that are micrometeorites have signs of their previous fusion: they have spherical shapes, like small marbles.

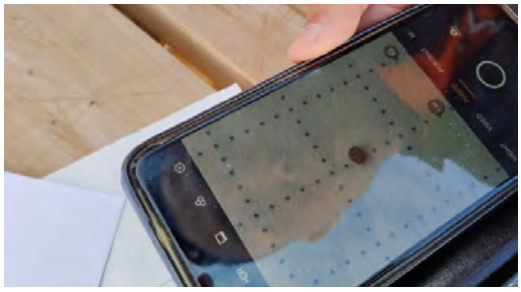


Fig. 9: Using a mobile phone camera with zoom (Credit: Rosa M. Ros).

If you want to increase the magnification of the mobile camera, it is possible to put a drop of disinfectant gel (used during the COVID period) on the objective of the mobile camera, which acts as a magnifying glass (figures 10a and 10b). But the truth is that it is not necessary, with a mobile phone camera it is perfectly possible to distinguish whether they are spherical or not. If available, a microscope can help to produce a good magnification.

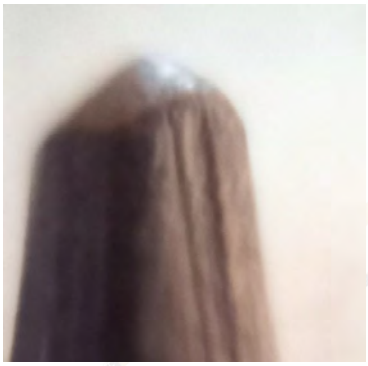


Fig. 10a: Photograph of a pencil lead with a mobile camera, Fig. 10b: Photograph of the lead using a drop of gel on the objective of the mobile or cell phone (Credit: Ricardo Moreno).

3) Research Work

After the separation and identification of the different micrometeorites in the sample, a record is achieved by acquiring photos with a cell phone, using the maximum possible magnification. This activity is already an important step in the framework of the proposal, because the participants are verifying the concepts shared at the beginning

of the experience, registering the evidence, and saving data (figures 11a, 11b , 12a and 12b).

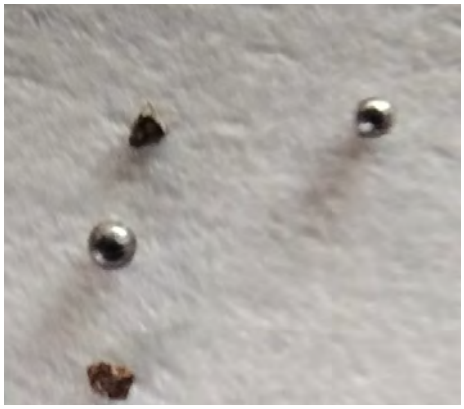


Fig. 11a: Photograph of a single isolated micrometeorite with the same camera, Fig. 11b: Photograph with several micrometeorites using a lens. (Credits Rosa M. Ros).

Fig. 12a: Looking the candidates to micrometeorites. Fig. 12b: Classifying the candidates. (Credits: Rosa M. Ros).

Moreover, the research work can be completed, trying to classify the micrometeorites by their morphology, differentiating their shape (not all of them are perfectly spherical, some are fused with others, etc) and produce a “gallery” of micrometeorites discovered by the “young scientists” that participate in the project.

NASE proposed to share these discoveries, sending some information about the different detected micrometeorites and evidence of the activity, such as photographs and documentation about individual identifications and those for which it was possible to classify according to their morphology, were received (table 2 and figures 13a, 13b, 14a, 14b, 15a, 15b, 16a and 16b).

Place: city, country	day month year	Number of micrometeorites	Is there any special morphology

Table 2: Collection of micrometeorites

Fig. 13a: Micrometeorite with some details in its surface from Cluj-Napoca (Romania). Fig, 13b: A special micrometeorite found in Viladecans (Spain) during the final event (Credit: Paula Chis).

.

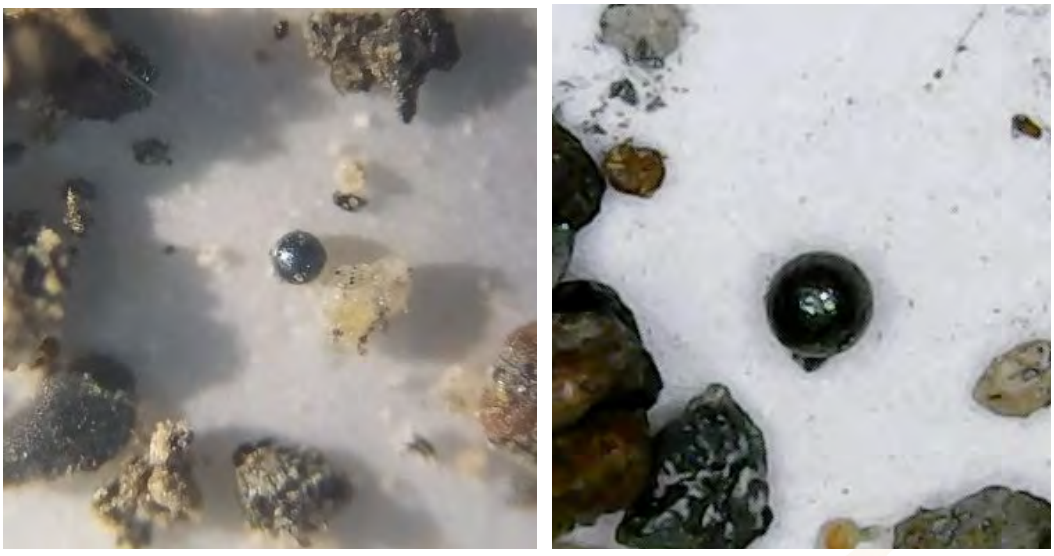


Fig. 14a and 14b: Spherical Micrometeorites brilliant and with different colours from Iran, but in any case are spherical brilliant and with metallic aspect (Credit: Hadi Babaee y Seyed Mahdi Mirfathi respectively)

Fig. 15a: Collecting micrometeorites in Qom, Iran. Fig. 15b Candidate Micrometeorites found. (Credit: Maryam Fartoosi and Maryam Karimi)

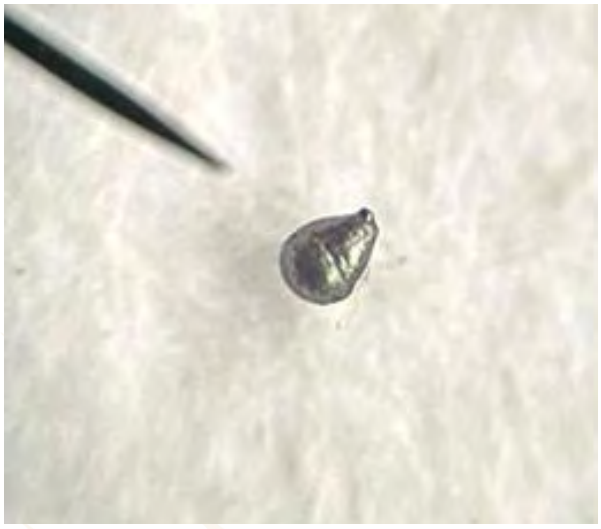


Fig. 16a and 16b: Candidates for micrometeorites with deformations and adhesions from Latvia. (Credit: Zigita Baldone).

2. Results Collection

Additions to the gallery of micrometeorites obtained is exciting, to inspire readers, to introduce some photographs of the experiments performed (figure 17) and the students collecting the material and studying micrometeorite candidates (figures 18 to 31).

Fig. 17: Preparing experiments in order to understand the shape of micrometeorites in Romanian High School (Credit: Corina Toma).

Fig 18a and Fig 18b. Looking for candidates to micrometeorites in Iran and China primary schools (Credits Syedeh Fatemeh Hasheminsasb and Xu Peng).

Fig 19: Preparing a trap to collect micrometeorite candidates in Benin (Credit: Pide Aristide Ahanhanzo)

Fig. 20a and Fig 20b: The excitement of finding possible micrometeorites in Iran and China (Credit: Seyed Mahdi Mirfathi y Xu Peng).

Fig. 21a and 21b: Students in Vietnam and Colombia observing the materials collected in their activities (Credit: Thảo Thiên Văn and Angela Pérez)

Fig. 22: Secondary and primary school students cooperating in the same school in Spain (Credit: Juan Antonio Prieto).

With the material collected, the students and teachers needed to consider it using several devices (mobile phones, microscopes etc.). Several teams integrated with university students and planetarium staff, participated in the project of NASE for the UNESCO International Day of Light 2023.

This project is really interesting for all people, the results are very similar, and then comparable, and on some occasions the students got many candidates in the same sample!

Fig. 23a and 23b: Students studying the micrometeorite candidates in Iran and Spain (Credit: M. Hosseinzadeh and Juan Antonio Prieto).

Fig. 24: Teachers checking candidates with their mobiles in Ecuador (Credit: Nicolás Vásquez)

Fig, 30: Members of Korea Science Academy of KAIST in Busan, South Korea (Credit: In Ok Song). Fig. 31: University students in Nicaragua participated in the NASE project with UNESCO from Universidad Nacional Autónoma de Nicaragua, UNAM-Managua, (Credit: Ligia Áreas)

Finally, each teacher and student received their “Certification of Participation”, as well as each organising centre, school, university, association or planetarium.

3. Exciting projects carried on by students and teachers in different countries

In 2023, and connected with the high impact of the proposal, the project “Micrometeorites” had been developed in many countries with different approaches and interesting peculiarities.

Some special examples are considered here:

- In China, more than 1000 students participated in the project
- A third of Iran’s population was involved in the project
- In Bulgaria, this project was the topic of the 19th edition of Astroparty.

All of them different and original possibilities to increase the interest of students in astronomy and in space sciences.

MOST (Micrometeorites Outdoor Searching Team) in China, promoted more than 1000 students involved

Dongni Chen, the vice-director of Beijing Planetarium, introduced the NASE Micrometeorites projects to the astronomy teachers in China in June, 2023. Xinyun Club in Zhongguancun No.2 primary school, which is the leading primary school astronomy club in Beijing, found this was a very interesting activity, and more than 100 members were involved. Geya Zhu, the instructor of Xinyun Club get a lot of help from Bin Yang, who is also from Beijing Planetarium, to initialize the projects.

When they found the students in primary school can learn a lot by using simple tools to find stardust in our surroundings, they try to set Zhongguancun No.2 primary school as sample to show how to introduce astronomy to kids. The numbers of students in Zhongguancun No.2 primary school is more than 7600 and the Xinyun Club is very popular in these students.

Six students from Xinyun Club (figure 32) build a team named MOST (Micrometeorites Outdoor Searching Team) and planed series of activities, including group discussion, online meeting, live streaming on social media and outdoor practices, to promote the search for micrometeorites. They took full advantage of School TV, which broadcast live to more than 2500 students in class. They acted as “junior teachers” and taught students how to make micrometeorite searching tools step by step in classes. They also provided links to “easy to do” videos in this broadcasting and many students see these videos later when they get home and involve in later activities.

Fig. 32: MOST members in China (Credit: Geya Zhu)

By using this method, they attracted more than 500 students to join the online streaming in social media to show details of how to search for micrometeorites.

With their own tools, they organized more than five outdoor groups searching with more than 1000 participants. The searching processes were then introduced to other schools, such as Lenghu primary school in Qinghai (figures 33a, 33b, 34a and 34b).

Fig 33a and 33b: MOST members working with the youngest students (Credit: Geya Zhu)

Fig 34a and 34b: Looking for micrometeorites. (Credit: Geya Zhu)

A third of Iran involved in the micrometeorites project

The micrometeorite project offered a remarkable opportunity for teachers nationwide to bring the wonders of the cosmos into their classrooms, inspiring and educating students. It allowed students not just to gaze at the stars but to physically connect with a piece of the cosmos, adding an intriguing dimension to the project.

The Thaqib Astronomy Community, one of Iran's oldest and most active amateur astronomy groups, played a crucial role in announcing the project through various channels, including their website, social media platforms, and letters to schools.

Fig. 35: Students in Qom, Iran, studying the material located in order to find candidates for micrometeorites (Credit: Mohammad Reza Moradi).

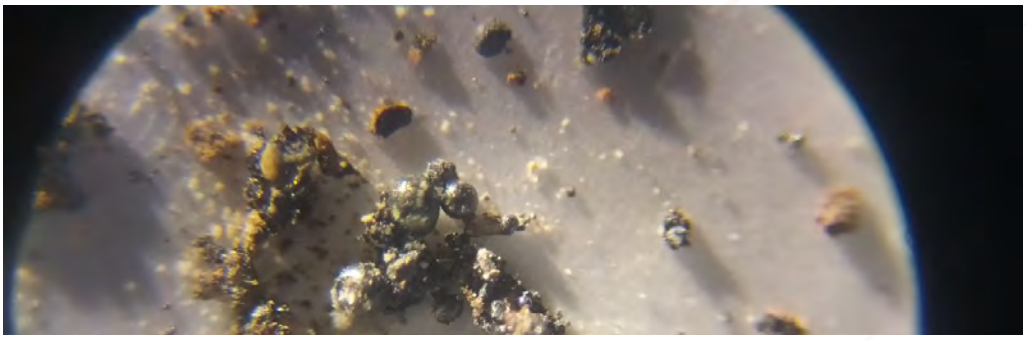


Fig. 36: There are some examples of micrometeorites candidates here. (Credit: Hadi Babaee).

Fig. 37: They located hundreds of micrometeorite candidates in Iran. (Credit: Mehdi Norouzibakhsh).

Additionally, collaboration with Kanon, the Institute for the Intellectual Development of Children and Young Adults, expanded the project's reach. Kanon's extensive network across various Iranian cities facilitated the distribution of letters and project materials to branches countrywide. This collaboration brought together astronomy enthusiasts, students, and educators from diverse locations, including remote villages (figures 35, 36 and 37).

Fig. 38: Map of the distribution of participating provinces in the micrometeorite project in Iran. (Credit: Fateme Hasheminasab)

At the end of the project, 212 students and 38 teachers in 26 school from 13 cities from nine provinces in Iran actively participated (figure 38).

National ASTROPARTY in Bulgaria, after 19 events, this year focusing in micrometeorites

For the 19th time in a row, on May 19 and 20, 2023, the National Astro Party was held on the beautiful bank of the Danube River near Baykal village, Dolna Mitropolia municipality, in Bulgaria. The event was under the patronage of the Minister of Education and Science and the mayor of the municipality of Dolna Mitropolia with the IAU and NASE as international partners. The main theme of "Astroparty Baikal" 2023 was "Journey into the universe - new discoveries and observations" (figure 39).

Fig. 39: Astroparty Baykal announcement (Credit: Ivo Jokin)

Participants were 45 students and 18 physics teachers from Bulgaria. At the traditional round table "From teachers for teachers", Ivo Jokin presented methodological guidelines for the "Light, cameras and life" project. In the Astroworkshop, participants worked on the mentioned project looking for micrometeorites, a NASE-IAU project, and conducted experiments with impact craters.

The students from the Astro Club at the Municipal Centre made 60 "micrometeorite search kits" themselves, which were distributed to the participants of the Astro Party (figure 40). Participants and students received certificates of participation.

Fig. 40: One of the 60 “micrometeorite search kits” distributed during the Astroparty in Bulgaria (Credit: Rosa M. Ros).

Fig. 41: Students and teachers looking for micrometeorites (Credit: Ivo Jokin)

The project was popularized in one of the most popular and widely read astronomy publications “Telescope” journal (Jokin, 2023).

4. Analysis of some micrometeorite candidates

This new project of NASE involved in the UNESCO International Day of Light, about micrometeorites, was a very interesting one. We did it in Cluj-Napoca, Romania, in our schools, with students from 12 to 16 years old. The material was looked for in the gutters, which collect the material that is deposited on the roofs, or in the rain gully of the school yard.

During these activities the students learned also about the different layers of the Earth atmosphere and how to explain the process of acquiring the spherical shape of micrometeorites. Some of them made collections and photo albums with possible micrometeorites. They are very interested in micrometeorites, so we decided to continue this project during the next course using different scientific methods, optical and electronic imaging.

Fig. 42a: Students looking for micrometeorites in Cluj-Napoca, Romania, Fig. 42b and 42c: Two examples of micrometeorites candidates (Credit: Paula and Ambrozie Chis)

After we collected it with a magnet and sort it by shape, we studied it through lenses and took photos using a smartphone with a 100X attached microscope. Some of these can be considered as good candidates for being micrometeorites.

We think that according with the criteria established by Genge (Genge and other, 2008) our spherules are good candidates to be micrometeorites since they meet at least 2 or 3 essential features: magnetite shell, Ni bearing iron metal, chondritic composition. Chondrites has a composition consisting largely of iron, magnesium, silicon and oxygen. The most abundant constituents of chondrites are chondrules, which are igneous particles that crystallized rapidly in minutes to hours (Evatt and other, 2020).

In collaboration with specialists in spectrometry (ICIA Cluj-Environmental analysis laboratory and the Faculty of Physics of Babes-Bolyai University, Cluj-Napoca) we found the composition of two candidates. Using a Tescan Vega 3, high vacuum model of SEM with 3-axis motorized stage for investigation of small conductive samples. A favourable package of a scanning electron microscope fully integrated with a selected EDX microanalyzer, here are some pictures and composition results for each candidate.

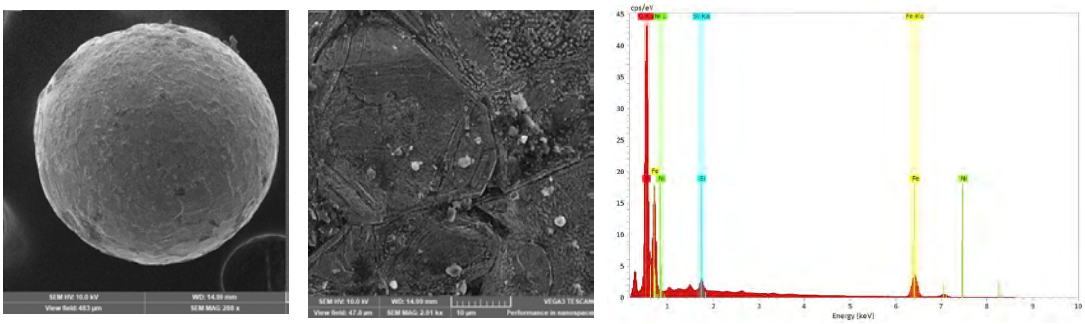


Fig. 43a: Micrometeorite candidate 1, Fig. 43b: Detail of the micrometeorite candidate, Fig. 43c: Candidate 1 composition (Credit: Paula and Ambrozie Chis).

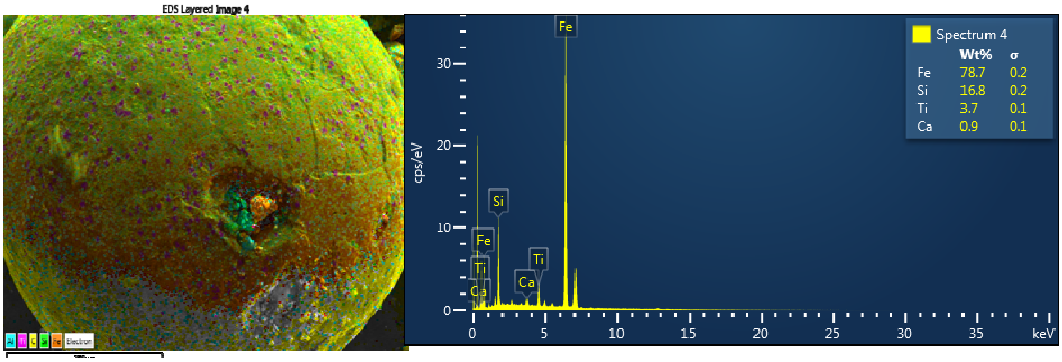


Fig. 44a: Micrometeorite candidate 2, Fig. 44b: Candidate 2 composition (Credit: Paula and Ambrozie Chis).

Element	At. No.	Mass (%)
Fe	26	64.84
O	8	32.40
Si	14	1.46
Ni	28	1.29

Table 3: Composition of candidate 1.

Element	At. No.	Mass (%)
Fe	26	78.7
Si	14	16.8
Ti	22	3.7
Ca	20	0.9

Table 4: Composition of candidate 2

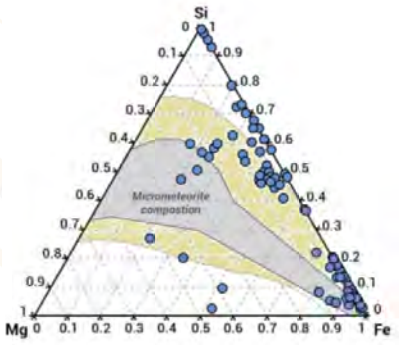


Fig. 45. Ternary plot of the high-density minerals in a micrometeorite. (Credit: Paula and Ambrozie Chis).

Micrometeorites are made of different chemical elements so, as a consequence there are different types / categories of micrometeorites. Also, we compared the composition of micrometeorites using this chart of figure 45 (Grier and others, 2019). The composition of both candidates have iron but one of them has also Ni which makes it a better candidate to be a micrometeorite (Suttle and other, 2021).

5. Searching for micrometeorites in Viladecans in person

In the project “Light, Cameras and Life 2023”, we have participating 28 countries from 4 continents distributed in all latitudes: Algeria, Argentina, Armenia, Benin, Bulgaria, China, Colombia, Dominican Republic, Ecuador, Ethiopia, Finland, Germany, Greece, Guinea Conakry, India, Iran, Latvia, Mongolia, Nicaragua, Panamá, Paraguay, Portugal, Romania, South Korea, Spain, Uruguay, USA and Vietnam.

At the end we collected 180 reports carried out in primary and secondary schools and centres, as well as by some universities, planetariums and observatories. It is not possible to calculate the total number of students involved, but it is possible to estimate a significant growth in participants, compared with previous projects of NASE integrated in the UNESCO Day of Light.

All the results received reports are displayed on the NASE website:
https://www.naseprogram.org/proiecte-iau-unesco/micrometeorites/

The project finished in a face-to-face event at the final of Science in Action (Science on Stage Spain) in Viladecans, near Barcelona on October 27th to 29th.

The organization had planned to place a set of tents in different parts of the town to receive the visit of thousands of school children who were expected to carry out the activity. With the advice of several groups of foreign and local teachers who would explain the process to follow and offer students the option of looking for candidates of micrometeorites themselves and back at home with a sample.

On this occasion we looked for candidates to micrometeorites using only two of the methods mentioned before (methods 1 and 3). Of course, we worked with students for only one day and we could not use the method of “trap” because it means collecting material over several days in advance.

In summary:

- We collected material in gutters and road ditches with a brush and using a magnet inside a paper pocket, moved the collected material and separated the ferromagnetic part of it. (figure 46)
- We invited the students to use the individual micrometeorite “trap” with a paper cup, a string and a small magnet (figure 47)

All the students were able to take the candidates found by themselves (figure 46).

Fig. 46: In the street, students collect sand and grit where we can locate meteorites. With a piece of paper we prepare a pocket, put a magnet inside and we move over the materials collected. The magnet will attract the candidate micrometeorites and we can observe them with a lens, mobile, or microscope in order to localize the spherical ones. (Credits Rosa M. Ros).

Fig. 47: The students can use the trap with the paper cup and the magnet in order to locate candidate micrometeorites. When some are detected, we can fix them with scotch tape. (Credits: Rosa M. Ros).

Fig. 48: Students show their candidates to micrometeorites.(Credits : Rosa M. Ros).

One of the objectives of both the International Astronomical Union and NASE is the development of scientific activities within the framework of Citizen Science initiatives and the communication of Astronomy with the general public and this event it was a good example of this kind of initiative.

Teachers from the countries that participated in person in this event (Armenia, Bulgaria, Germany, Mongolia, Romania and Spain) had the opportunity to share their experience (in addition to show the materials) with the other classmates and enjoy the Science in Action fair that was developed not simultaneously with the NASE project.

More than 500 students from Viladecans enrolled in their educational centres (Escola Montserratina, I.E.S. Sales, I.E.S Olímpia, I.E.S. Torre Roja I.E.S, Miramar). Every 30 minutes a new group of 20-25 students, aged between 6 and 18, would arrive and take part in the experiment and then give up their place to the next group. The process took place throughout the morning of October 27th.

The groups of teachers were arranged in 5 places whose locations were:

- Centre 1: Escola Montserratina Primary School (figures 49, 50 and 51) with teachers from Armenia and Spain.
- Centre 2: I.E.S. Sales Secondary School (figures 52, 53 and 54) with teachers from the Mongolia and Romania and Spain.
- Centre 3: I.E.S. Olimpia Secondary School (figures 55, 56 and 57) with teachers from Mongolia and Romania.
- Centre 4: I.E.S. Torre Roja Secondary School (figures 49 and 57) with teachers from Germany and Spain
- Centre 5: I.E.S. Miramar Secondary School (figures 52, 53 and 54) with teachers from Bulgaria and Spain.

Fig. 49: In the court of Escola Montserratina, the team from Armenia and Spain beginning to introduce the activity to the primary school students. (Credit: Rosa M. Ros).

Fig. 50: Escola Montserratina with the team from Armenia and Spain collecting candidates of extra-terrestrial material. (Credit: Rosa M. Ros).

Fig. 51: Escola Montserratina with very motivated students looking for micrometeorites (Credit: Rosa M Ros).

Fig. 52: IES Sales where the teams from Mongolia, Romania and Spain were installed (Credit: Rosa M. Ros)

Fig. 53: Teacher from Romania and some students in IES Sales determining possible candidates with a lens. (Credit: Rosa M Ros).

Fig. 54. Teacher from Mongolia showing material collected (Credit: Rosa M Ros).

Normally the session began with a short introduction about how the micrometeorites arrive at the surface of the Earth and the reason that they appear as small spheres (figure 55a and 55b)

Fig. 55a: Mongolian teacher from Education Centre “Extremum” and NASE member preparing the micrometeorites Fig. 55b: Student repeating the experiment in the IES Olimpia (Credit: Paula Chis).

At the beginning, the students collected several candidates that after a critical study by optical devices (phone with specific app, lens or a microscope (figures 56, 57a, 57b, 58 and 59)) the objects could be considered as a serious candidate to be micrometeorites. A more accurate analysis was not possible at this moment.

Fig. 55: Romanian professor and NASE member studying candidates to micrometeorites in the IES Olimpia (Credit: Rosa M. Ros).

Fig. 57a: A Mongolian team member of Ulaanbaatar Observatory and NASE considering several candidates by means of the app of his mobile phone, Fig. 57b: One of the micrometeorites candidates found by this group. (Credit: Rosa M Ros).

Fig. 58: Teacher from Germany looking for candidates with a digital microscope (Credit: Rosa M Ros).

Fig. 59. Teachers from Spain and Germany introducing devices in order to determine candidates for micrometeorites (Credit: Rosa M Ros).

Fig. 60: Teachers from Bulgaria and Spain introducing the essential concepts of micrometeorites before beginning the activities in the IES Miramar (Credit: Rosa M. Ros).

Fig. 61: Students satisfied with their candidates for micrometeorites in the IES Miramar (Credit: Rosa M. Ros).

Fig. 62: A teacher from Bulgaria advising a candidate and the student was satisfied afterwards to find a possible micrometeorite in the IES Miramar (Credit: Rosa M. Ros).

In all cases, the students were looking for micrometeorites was an important success. The activity was not only amusing, but formative and the possibility to have a sample of extra-terrestrial material to inspect at home, transformed the experience into one which continued beyond the time of the fair.

6. Detection of micrometeorites by density

As only about 97% of all micrometeorites are magnetically attracted and some only very weakly, an additional method could be: first collecting much material and then distinguish everything by density rather than by magnetism. This idea is supported by many literature works (e.g. Suttle et al., 2021).

To collect much material a hand brush and a dustpan can be used. To extract the micrometeorites with higher density, a Gold-washing Pan stirring the material gently with water can help to let the denser micrometeorites sink to the bottom.

A further advantage of this method is that you can even use wet material in case of collecting while it is raining. And additionally wind only harms the collection on paper and not as much as the collection with hand brush and dustpan.

Fig. 63a: Using a gold-washing tray, the water can be decanted and the denser materials left at the bottom of the tray. Fig. 63b: Spherical micrometeorites appear in the background, although they are not ferromagnetic since the effect of magnetism has not been used to detect them (Credit: Stefan Müller-Champrenaud).

7. The closing event of “Light, cameras and Life”

The closing online session held on October 28th, 2023 was streamed worldwide, recorded, and can be viewed on the NASE YouTube channel, at the following link: : https://www.youtube.com/watch?v=fx81kJL5IoQ&t=8221s

Some of the assistants were in Spain in person, they were all the teachers who made up the 5 groups who gave the sessions the day before.

This hybrid event had the advantage to open the stage for the participation and collaboration of people from many places. Part of the face-to-face and online participants presented contributions on the topics of the call.

Before beginning the online transmission of this final, the Deputy Mayor of Promotion of Science and Scientific Dissemination of Viladecans (figure 64) said goodbye to all the 15 visiting professors (2 Armenia, 2 Bulgaria, 1 Germany, 3 Mongolia, 2 Romania and 5 Spain) explaining in detail the interest of the city of Viladecans for citizen science and for the promotion and encouragement of new STEM vocations, totally in line with the objectives of NASE.

Fig.64: Recognition by the Deputy Mayor of Promotion of Science and Scientific Dissemination of Viladecans to the visiting professors invited for the IAU-UNESCO project presented by NASE as a Great Science in Action Experience of Science in Action 2023 (Credit: Rosa M. Ros).

The agenda of the meeting included the following topics:

- ***Opening session***, Beatriz García and Rosa M. Ros, Argentina and Spain.

- ***"Searching for micrometeorites with students in Zhongguancun No.2 primary school students"***, Geya Zhu, Zhongguancun No. 2 Primary School, Beijing, China.

- ***"NASE project on Micrometeorites in Iran"***, Fateme Hashemi Nasab, ITAU,Bushehr, Iran.

- ***"City stardust: Comparison between two micrometeorites"*** Ambrozie Chis and Paula Chis,George Baritiu School, Cluj, Romania.

- ***"Micrometeorites from the middle of the world in Latin America"*** Nicolas Vasquez, Escuela Politecnica Nacional, Quito, Ecuador.

- ***"Observations of ablating micro-meteoroids using high-power and large-aperture radars"*** Qihou Zhou, Miami University, USA.

- ***"Summary of "Micrometeorites in Viladecans""***, Ivo Jokin, Bulgaria; Stefan Müller-Champrenaud, Germany; Bayarkhuu Chinzoring, Mongolia; Varduhi Mkrtchyan, Armenia.

- ***"Will we see the constellation of Orion without the star Betelgeuse on December 12th?"*** Antoni Selva, Associació Astronómica de Sabadell, Sabadell, Spain.

- ***Closing Session***, Beatriz García and Rosa M. Ros, Argentina and Spain.

Fig.65: Fateme Hasheminasab of ITAU and NASE member presenting the activity of students and teachers in Iran. (Credit: Beatriz García).

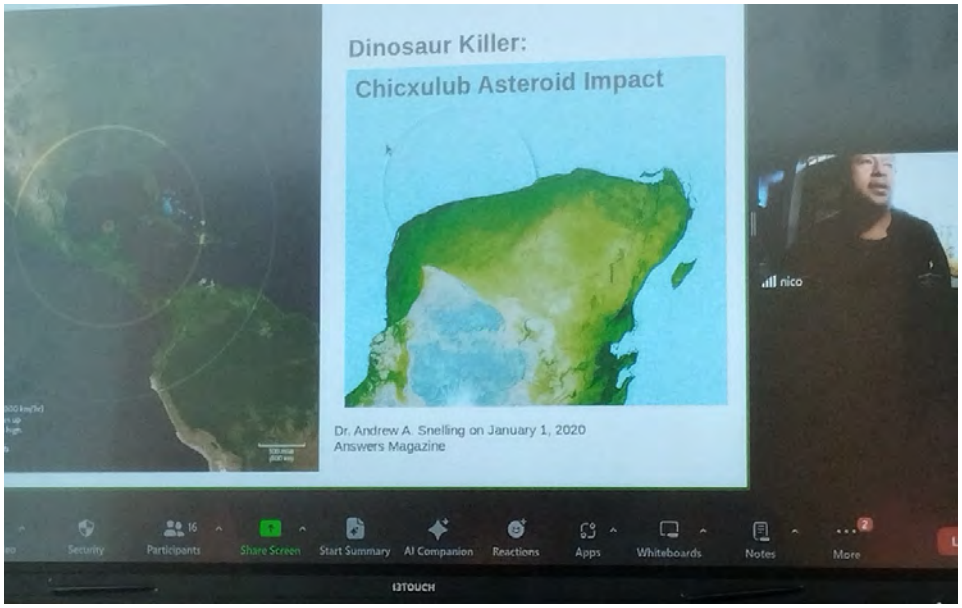


Fig.66: Nicolas Vasquez of Universidad Politécnica de Quito and NASE member presenting the summary of American reports presented in this project. (Credit: R.M. Ros).

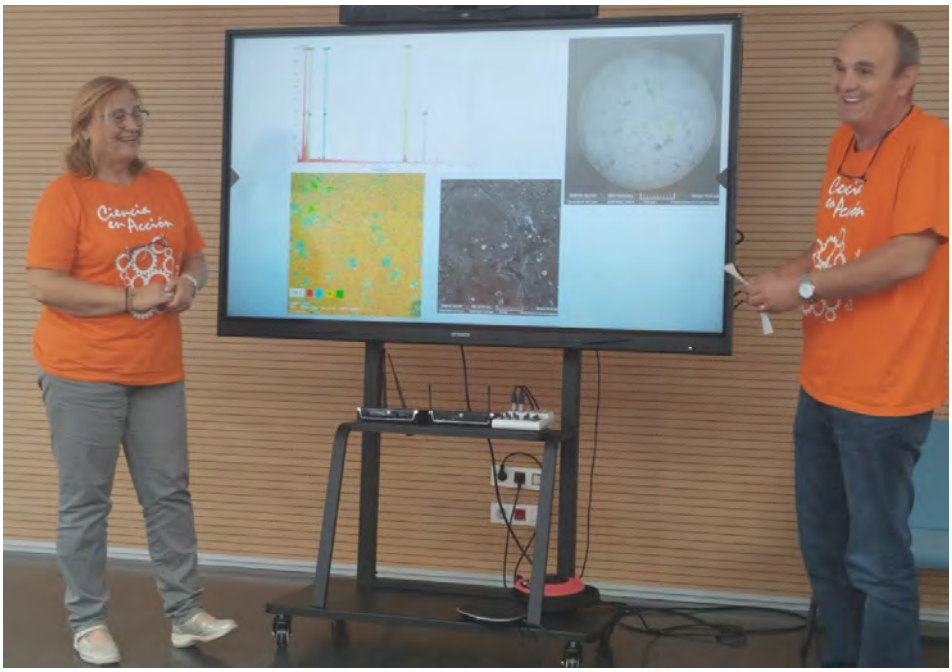


Fig. 67: Ambrozie and Paula Chis showing their contribution about the micrometeorites analysed (Credit: Rosa M. Ros).

One of the presentations, how could it be otherwise, briefly and simply summarized the Great Experience of the previous day. The authors of this presentation were Ivo Jokin, Stefan Mûller-Champrenaud, Bayrkhuu Chinzoring and Varduhi Mkrtchyan from Bulgaria, Germany, Mongolia and Armenia respectively. Figures 64 to 69 show some special moments of the encounter.

Fig. 68: Summarizing the Great Experience of the previous day so that the online attendees knew the results of it. A very interesting experience that was valued very positively by the students and their teachers. (Credit: Paula Chis).

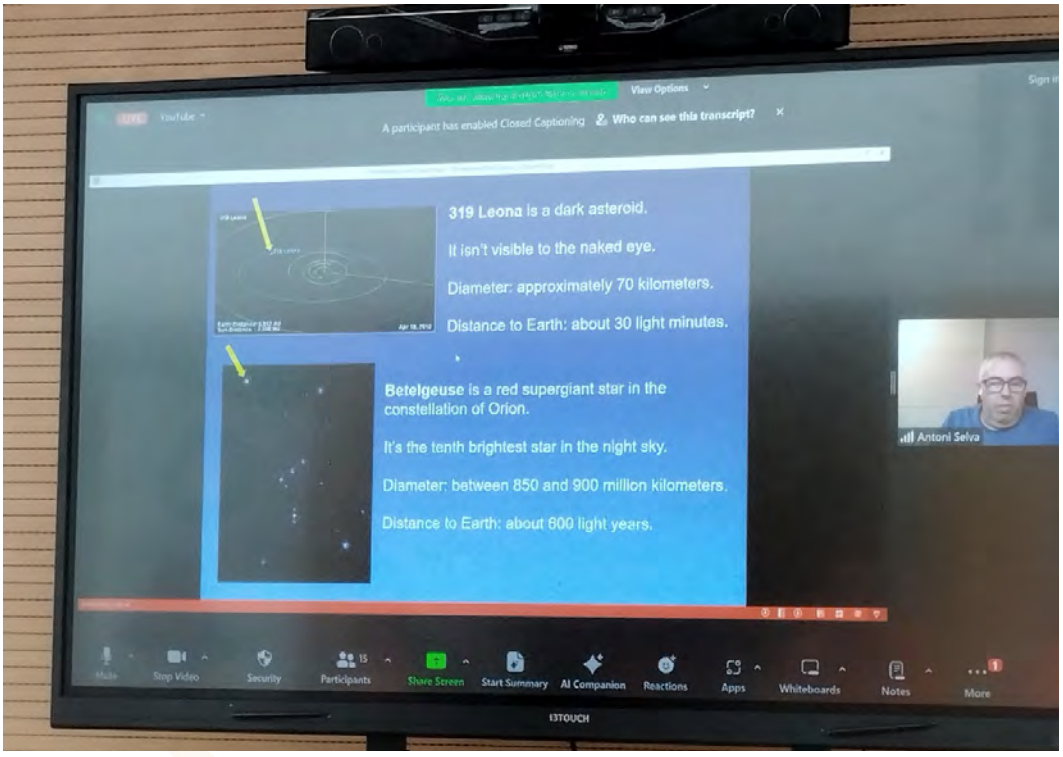


Fig. 69: Antoni Selva, the last speaker in the online session introduced the next NASE event that will take place on December 16th, related to the Betelgueuse Occultation. This was a project suggested by Jay Pasachoff who died in 2022 and NASE will organize in memoriam (Credit: Rosa M Ros).

7. Results & Conclusions

In this 6th NASE-UNESCO project edition, the program received more than a hundred and eighty written reports. These works can be seen on the NASE website. The distribution on the Globe, is detailed in figure 70.

Fig. 70: Distribution by continents of the works received (Credit: Lucas Torres).

The majority of reports included photos of the micrometeorites found, but some of them explain what they did in detail, and also, the cases in which the students could not find any: a negative result is also a scientific one and an opportunity to learn about the troubles in experimental research. In general, the results were provided by primary and secondary schools, but there were some reports made by universities, observatories, association of teachers and planetariums.

The most important thing is not the quality of results (which were really nice), but the interest promoted, the impact of the proposal and the understanding of the processes carried out.

“Light camera and Life” was not only a project to find micrometeorites, but it was also something more interesting for students. They needed to prepare many aspects themselves before beginning to look for micrometeorites. They can prepare several activities depending on the kind of projects that students decide to plan. In some cases, they organized a series of activities, including group discussion, online meetings, live video on social media and outdoor practices, to promote the searching of micrometeorites. These activities attract a lot of people to join and several micrometeorites candidates were found.

The key point of the project were that kids like the idea of finding extra-terrestrial materials, the activities are “easy to do” because the materials are easy to get and using social media they can find more information and distribute it.

The most important thing is not the micrometeorites found, but understanding the process carried out to get them and realise that it is easy to find extra-terrestrial material, and extend the research beyond the detection, to other topics connected, for example, with the astrochemistry and the astrobiology, to discover the origin of life on Earth.

Acknowledgements:

NASE would like to give thanks to all the institutions which support these initiatives:

Cité de la Science en Túnez, Túnez
CLEA, Comité de Liaison Enseingants et Astronomers, France
CONICET, Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina
CSIC, Consejo Superior de Investigaciones Científicas, España.
Entoto Observatory, Ethiopia
ESSTI Ethiopian Space Science Society, Ethiopia
Institut für Astrophysik, University of Wien, Austria
Institut Teknologi Bandung, Indonesia
Instituto de Astrofísica e Ciências do Espaço, Portugal
ITAU Iraian Teacher's Astronomy Union, Iran
ITEDA, Instituto de Tecnologías en Detección y Astropartículas (CNEA-CONICET-UNSAM), Argentina
ITERA Institut Teknologi Sumatera, Indonesia
SINA Students Iranian Network for Astronomy, Iran
NARIT National Astronomical Research Institute of Thailand
Planetario de Beijing, China
Planetario de Oporto, Portugal
Universidad Nacional de Cuyo, Mendoza, Argentina
University of Oporto, Portugal

BIBLIOGRAPHY

Belmonte J.A., Berthomieu F., Costa A., Deeg H., Deustua S., Fierro J., García B., Hemenway M.K., Moreno R., Pasachoff J.M., Percy J., Ros R.M., Stavinschi M., 2018, ***14 steps to the Universe***, Ros R.M. and Hemengway M.K. edi.

Evatt, G., Smedley, A., Joy, K., Hunter, L., Tey, W. H., Abrahams, L. D., & Gerrish, L., 2020. The spatial flux of Earth's meteorite falls found via Antarctic data. Geology, 48(7), 683-687. https://doi.org/10.1130/G46733.1

Genge M.J., Engrand C., Gounelle M., Taylor S., 2008, The classification of micrometeorites. Meteoritics & Planetary Science 43 Nr. 3, 497-515

Grier J.A., Rivkin A.S., 2019, The creation of regolith and soils-Impact Cratering and other Processes. Airless Bodies of the inner solar system

Jokin, I., 2023, "Two teachers from the municipality of Dolna Mitropolia represented Bulgaria at an international festival "Ciencia en Accion" in Spain", Telescope 50, 1153

Ros, R.M. & García, B., 2023. 3rd Book: Bridges Between Cultures: Looking for Micrometeorites, Eds., Zenodo. https://doi.org/10.5281/zenodo.8223805

Suttle M.D., Hasse T., Hecht l., 2021. Evaluatingureban micrometeorites as a research resource- A large population collected from a single rooftop. Meteoritics & Planetary Science 56 Nr. 8, 1531-1555.