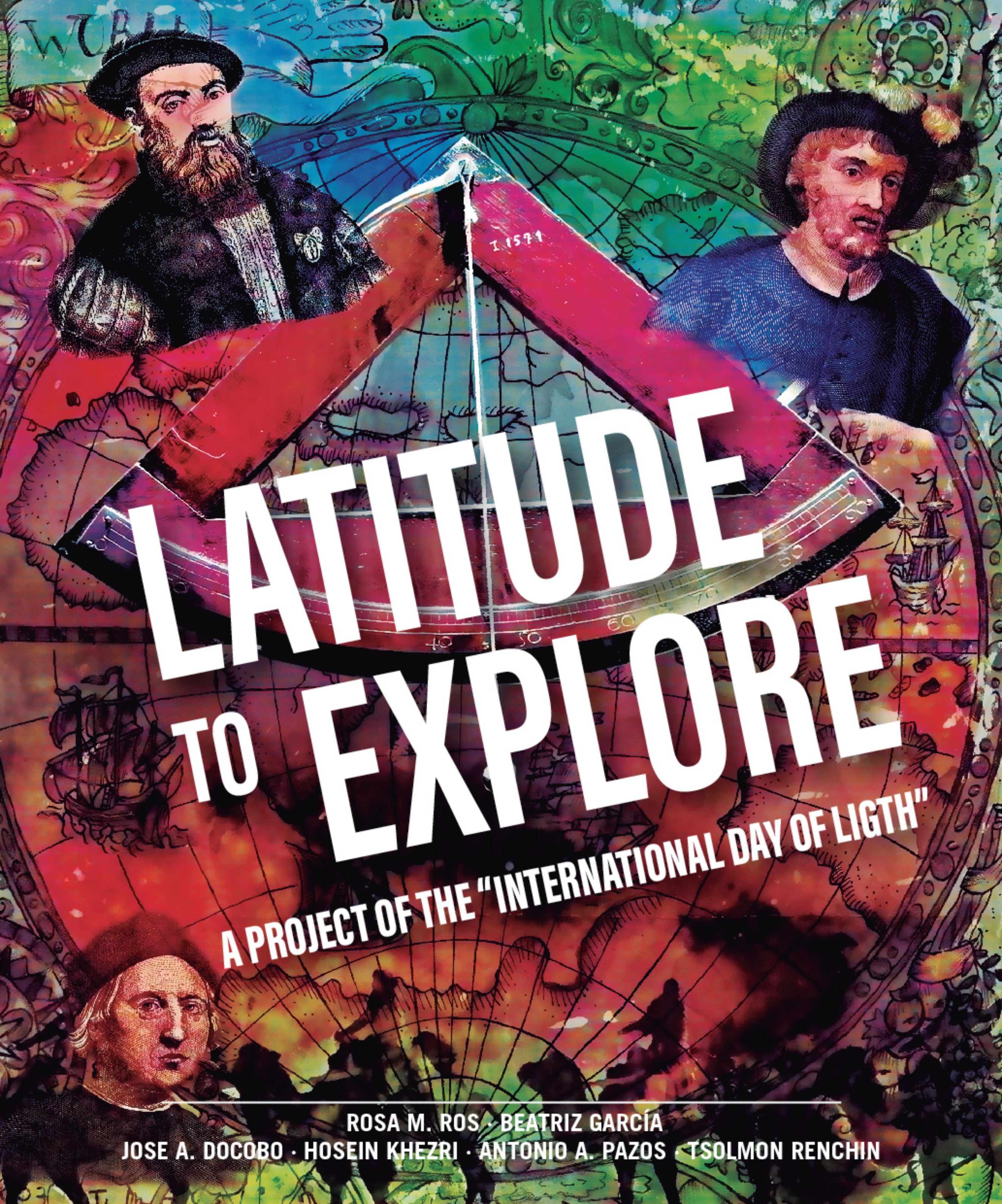
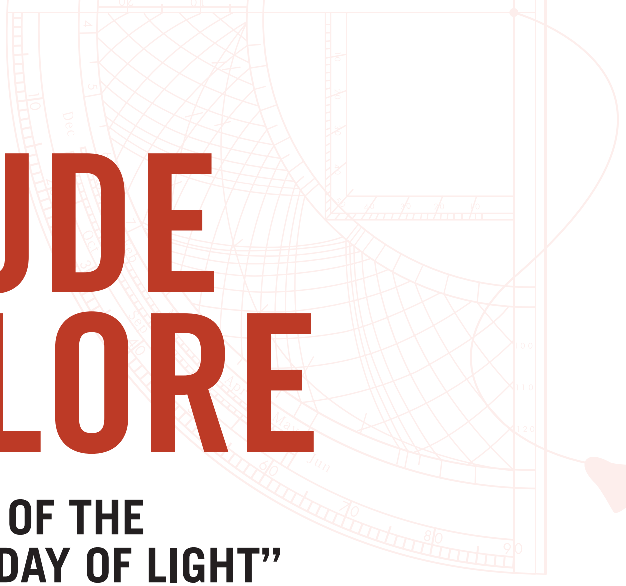


LATITUDE TO EXPLORE

A PROJECT OF THE "INTERNATIONAL DAY OF LIGTH"

ROSA M. ROS · BEATRIZ GARCÍA
JOSE A. DOCOBO · HOSEIN KHEZRI · ANTONIO A. PAZOS · TSOLMON RENCHIN



LATITUDE TO EXPLORE

A PROJECT OF THE "INTERNATIONAL DAY OF LIGHT"

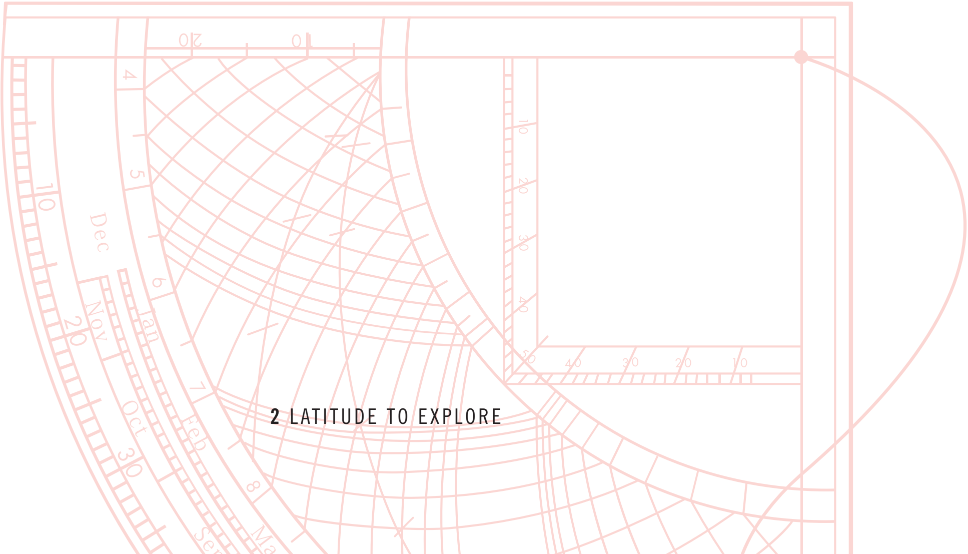
IAU
100 YEARS: UNDER ONE SKY

nase

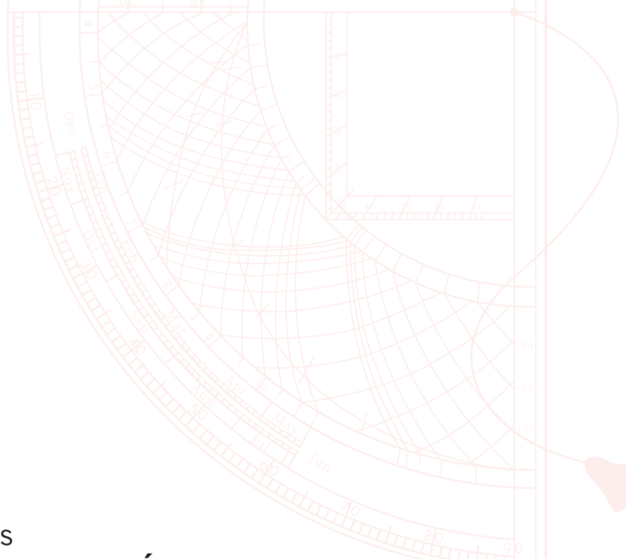
AJUNTAMENT DE
VILADECANS

United Nations
Educational, Scientific and
Cultural Organization

International
Day of Light



2 LATITUDE TO EXPLORE



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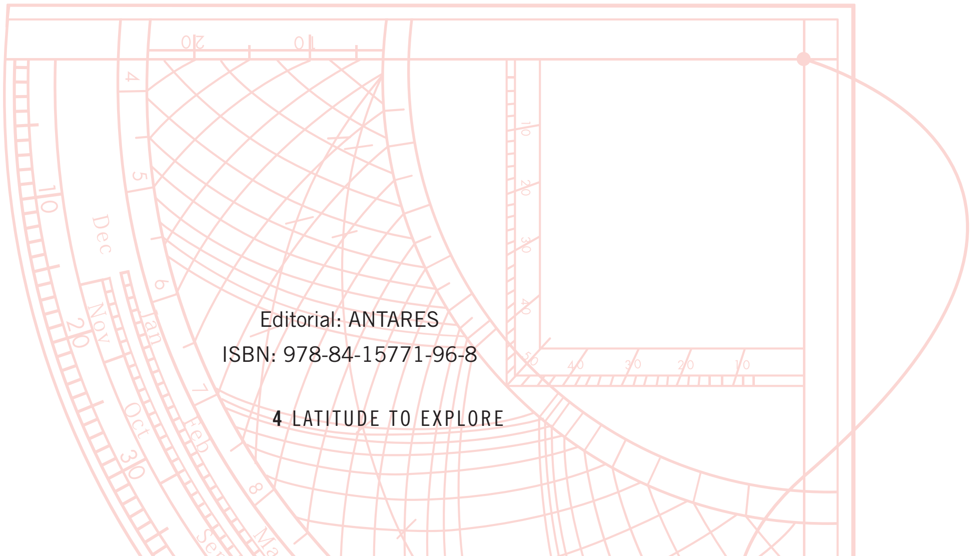


Editorial: ANTARES
ISBN: 978-84-15771-96-8

4 LATITUDE TO EXPLORE

Science in Action once again explores the fascination for science in Viladecans

At Viladecans we are proud to have hosted this year's 2022 edition of the Science in Action contest and activity program in our city. From October 7 to 9, the objective of all participants and organizations has been to bring science to all citizens and, especially, to families with children, in a fun and motivating way.

It has therefore been a real pleasure to be able to share Viladecans for a few days with teachers and students from all over Spain, with the organization of the event and with the members of the jury, who this year have found it even more difficult than in other editions due to the high quality of the works submitted to the contest. I hope we meet again in other editions and continue to bring the fascination of scientific magic everywhere.

Our city is the fourth most populous municipality in the Baix Llobregat region and the nineteenth in Catalonia. With a compact urban nucleus, which occupies a third of the entire municipal area, and a great variety of geographical spaces from the beach to the mountains, passing through protected natural areas and agricultural land, we are a city that invites you to visit and enjoy. A city that has not lost its spirit of the town that it was half a century ago and has developed an entrepreneurial character to multiply its potential.

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. A commitment consolidated with the attraction of investments and multinational companies, with the promotion of the diversification of activity sectors, with the support for entrepreneurship, the creation of companies and the local productive fabric, and with the training of professionals. Viladecans' objective of being a benchmark for economic dynamism in the region in order to emerge from the crisis with the best conditions has also ended up turning the city into a benchmark for quality of life. With a population younger than the Catalan average and more than fifty municipal facilities to guarantee public services, in Viladecans we have become over time an active, open, restless and non-conformist municipality in the face of inequalities.

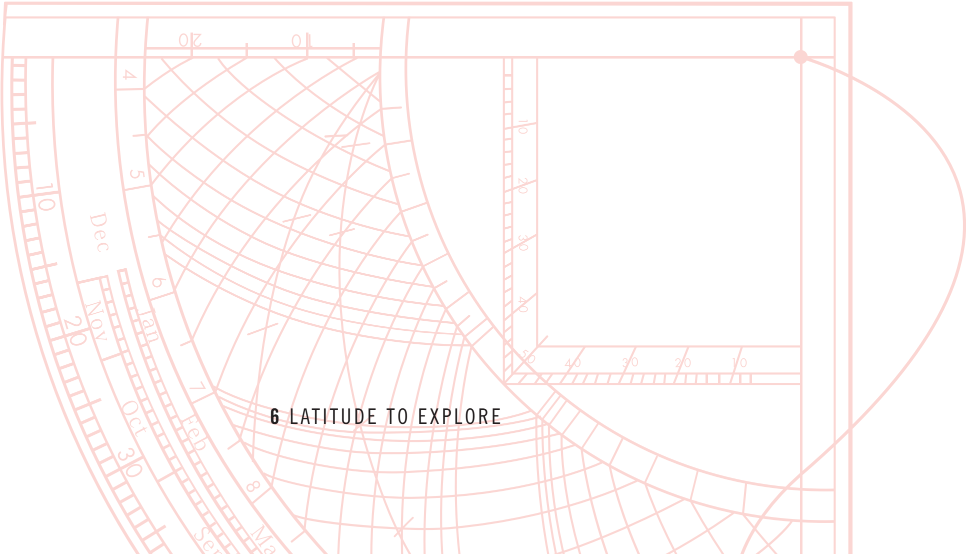
Projects like Science in Action fit perfectly with the objectives of Viladecans, where we emphasize educational success, innovation and the promotion of equal opportunities for citizens, a promotion to which education, science and culture are some of the fundamental pillars of the local government team. 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.

Thank you for choosing us as hosts this year. See you at the next contest!

A hug,

Carlos Ruiz Novella
Mayor of Viladecans

6 LATITUDE TO EXPLORE



The 2022 ‘Science in Action’ final took place in Viladecans, near Barcelona, Spain, and as in previous editions, the Great Experience corresponded to a project within UNESCO’s International Day of Light. As this year marked the 500th anniversary of the first circumnavigation of the world, this project focused on determining latitude using solar declination as 16th century navigators crammed. In this edition, the number of participating countries was 22 (Argentina, Benin, Bulgaria, China, France, Greece, Guatemala, Indonesia, Iran, Italy, Lithuania, Mongolia, Paraguay, Philippines, Portugal, Romania, Senegal, Spain, Tanzania, Togo, Turkey and United States) collecting a total of 150 works carried out by primary and secondary schools, universities and observatories.

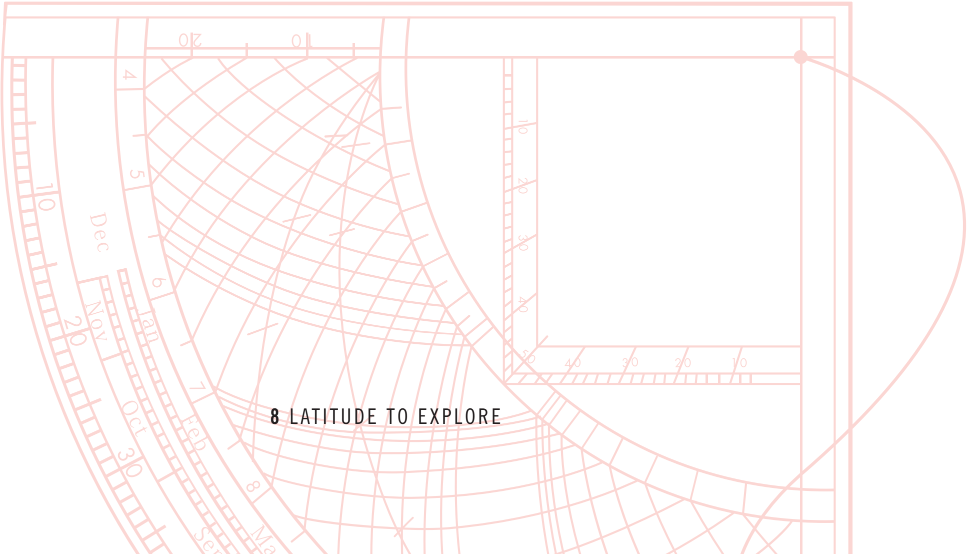
The project has collaborated with 20 international institutions (Cité de la Science en Túnez, Túnez, CLEA, Comité de Liaison Enseingants et Astronomers, France, CONICET, Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina, CSIC, Consejo Superior de Investigaciones Científicas, España, Entoto Observatory, Ethiopia, ESSTI Instituto Etíope de Ciencia y Tecnología Espacial, Ethiopia, Ethiopian Space Science Society, Ethiopia, IFA Instituto para Astrofísica de la Universidad de Viena, 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 Instituto Nacional de Investigación Astronómica de Tailandia, Planetario de Beijing, China, Planetario de Oporto, Portugal, Universidad Nacional de Cuyo, Mendoza, Argentina y University of Oporto, Portugal. These institutions have disseminated the Project mentioned throughout the world, from the March equinox to September. The program concluded with a face-to-face session on October 7th and an online session on October 8th.

Ten countries participated in Viladecans (Spain, the United States, the Philippines, France, Greece, Italy, Lithuania, Mongolia, Paraguay and Romania) that were distributed in various parts of the city of Viladecans, where local students had the opportunity to visit these spaces to learn about the project explained by the teachers involved in the Great Science in Action Experience project, this is Science on Stage Spain.

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 centers to the points where the demonstrations took place.

Rosa M. Ros Ferré
President of Ciencia en Acción Association

8 LATITUDE TO EXPLORE



Introduction

As in previous editions, NASE (Network for Astronomy School Education) prepares a project as a Great Science in Action Experience within the scope of the "International Day of Light", May 16, promulgated by UNESCO, calling for an activity for all the centres from the 70 countries in which NASE has been developed since its inception at the General Assembly of the IAU (International Astronomical Union) in 2009 in Rio de Janeiro.

The "Latitude to travel and navigate" project was developed from the March equinox to September 2022 and began with the synchronous online event "2º Bridges between Cultures". The final closing event took place in two ways: a face-to-face event on October 7 in the city of Viladecans (Barcelona, Spain) as a "Great Experience" of the international Science in Action program in the year of the 500th anniversary of the journey around the world by Magellan and Elcano.

Fig. 1: Group photo of the teachers who participated in the final face-to-face event in Viladecans (Barcelona) (Credit: RM. Ros).

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 four years.

For half of the year 2022, teachers and professors from all over the world have been able to carry out the experience of determining the local latitude with their students. A part of them (Figure 1) participated in Viladecans with the students of this city repeating the determination of Latitude throughout the morning of October 7. It is necessary to acknowledge 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.

The teachers and students during the active period of the project carried out the experience during the day, and depending on their latitude, at night, sending their results schematically as can be seen in Figures 2 and 3.

Latitude for travelling and navigate

Fig. 2. Ejemplo de resumen enviado desde uno de los colegios participantes (Saint Klimend Ohideki, Sofia, Bulgaria) (Crédito: IH Serafinova).

1. Latitude Determination

The latitude of the place L is defined as the angle on the terrestrial meridian from the equator to the place of observation, that is, from the equator to the vertical plumb line at the place where the observer is. Figure 3 is not to scale, since the radius of the celestial sphere is infinite and the radius of the Earth is only a little over 6000 km, so the Earth is really just a point. Thus the observer's horizon is reduced to the horizon that passes through the centre of the celestial sphere. The height of the pole above the horizon is also the latitude because this angle is determined by the axis of rotation (which is perpendicular to the equator) and the horizon (which is perpendicular to the plumb line).

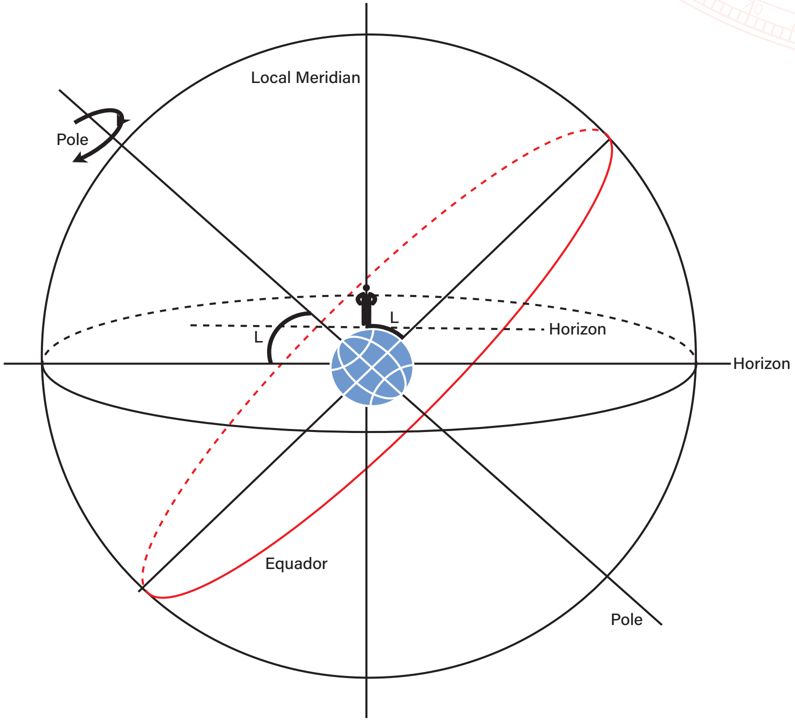


Fig. 3. The latitude coincides with the height of the pole (in the northern hemisphere)and the colatitude is the height of the equator at solar noon on the day of the equinox (Credit: E. Viñuales).

The determination of the latitude of the place can be done during the day or at night:

1) At night, the height of the pole above the horizon can be determined by looking for the height of the Pole Star, in the northern hemisphere, and for the southern hemisphere, the height of the point corresponding to the south pole with the help of the Southern Cross, but at that point there is no star visible without a telescope (in this second case the result is less accurate).

2) By day you can determine the height of the Sun at the measured day, when it passes through the meridian of the place (when it is at the highest point). On the day of the equinox, the Sun travels exactly along the equator, so the height of the Sun on that day is the colatitude, 90 degrees minus L.

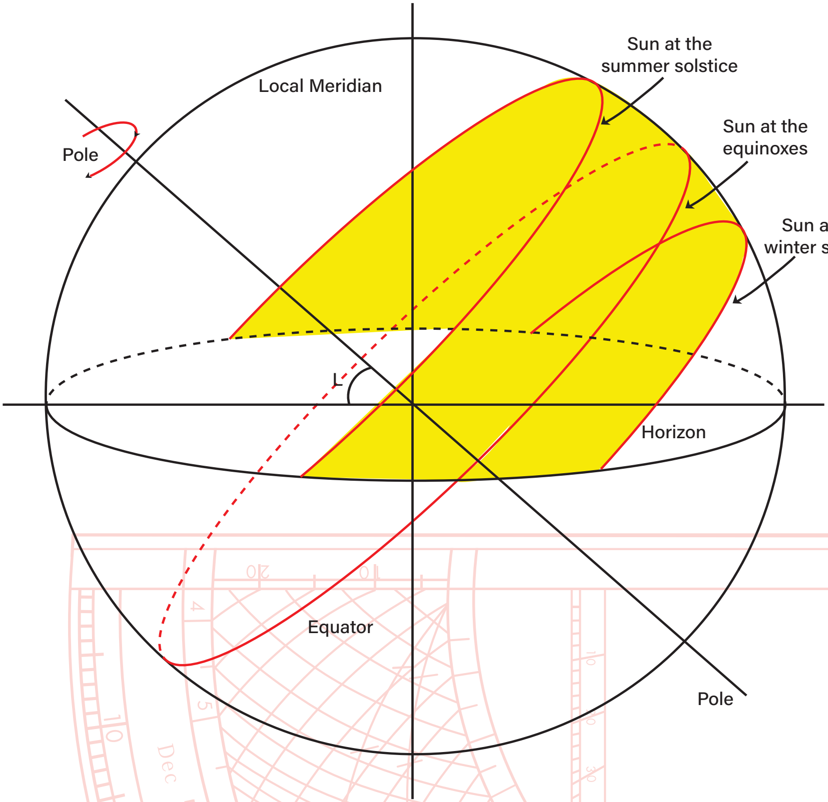


Fig. 4. The Sun moves parallel to the equator where the declination of the Sun varies from +23.5º above the Equator to -23.5º below it, giving rise to the two solstices (Credit: E. Viñuales). The Sun

always moves (in its apparent motion) parallel to the equator (Figure 4). Thus, the spring and summer months run parallel above the equator and the fall and winter months run parallel below the equator. From the equator to the day it moves at a lower altitude (first day of winter) there is -23º.5 and from the equator to the day it reaches the maximum height +23º.5 (first day of summer). The angle from the equator to the parallel where the Sun is on any given day of the year is called the solar declination.

When navigators approached the equatorial zone, they could not determine latitude using the position of the pole, so they used to do it using the position of the Sun, on the understanding that they had the table of solar declinations. Let's see what the process is for a specific day. For example, October 7, which was the day selected to carry out the experiment in person at the Science in Action final

	Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Septiem	Octubr	Noviem	Diciemb
1	-23 03 09	-17 17 10	-07 50 19	+04 16 57	+14 52 25	+21 57 37	+23 08 56	+18 10 51	+08 31 15	-02 55 32	-14 12 39	-21 41 35
2	-22 58 17	-17 00 09	-07 27 33	+04 40 07	+15 10 36	+22 05 50	+23 04 58	+17 55 49	+08 09 31	-03 18 49	-14 31 54	-21 50 59
3	-22 52 58	-16 42 51	-07 04 40	+05 03 11	+15 28 32	+22 13 39	+23 00 36	+17 40 28	+07 47 40	-03 42 03	-14 50 56	- 21 59 58
4	-22 47 11	-16 25 14	-06 41 41	+05 26 11	+15 46 13	+22 21 05	+22 55 50	+17 24 51	+07 25 41	-04 05 15	-15 09 43	-22 08 32
5	-22 40 57	-16 07 21	-06 18 37	+05 49 04	+16 03 38	+22 28 08	+22 50 39	+17 08 56	+07 03 34	-04 28 24	-15 28 15	-22 16 40
6	-22 34 16	-15 49 11	-05 55 27	+06 11 52	+16 20 48	+22 34 47	+22 45 05	+16 52 45	+06 41 21	-04 51 30	-15 46 32	-22 24 23
7	-22 27 08	-15 30 44	-05 32 13	+06 34 33	+16 37 41	+22 41 02	+22 39 08	+16 36 17	+06 19 01	-05 14 33	-16 04 34	-22 31 39
8	-22 19 34	-15 12 02	-05 08 53	+06 57 08	+16 54 17	+22 46 54	+22 32 46	+16 19 33	+05 56 34	-05 37 31	-16 22 19	-22 38 28
9	-22 11 33	-14 53 04	-04 45 30	+07 19 35	+17 10 37	+22 52 21	+22 26 01	+16 02 34	+05 34 02	-06 00 25	-16 39 48	-22 44 52
10	-22 03 06	-14 33 51	-04 22 03	+07 41 55	+17 26 39	+22 57 25	+22 18 53	+15 45 19	+05 11 24	-06 23 15	-16 56 60	-22 50 48
11	-21 54 14	-14 14 23	-03 58 33	+08 04 08	+17 42 24	+23 02 04	+22 11 22	+15 27 48	+04 48 40	-06 45 59	-17 13 55	-22 56 17
12	-21 44 55	-13 54 42	-03 34 59	+08 26 12	+17 57 51	+23 06 19	+22 03 28	+15 10 03	+04 25 52	-07 08 38	-17 30 32	-23 01 19
13	-21 35 12	-13 34 46	-03 11 23	+08 48 08	+18 13 01	+23 10 09	+21 55 11	+14 52 04	+04 02 59	-07 31 12	-17 46 51	-23 05 54
14	-21 25 03	-13 14 37	-02 47 45	+09 09 56	+18 27 51	+23 13 35	+21 46 32	+14 33 50	+03 40 02	-07 53 39	-18 02 51	-23 10 02
15	-21 14 29	-12 54 14	-02 24 05	+09 31 34	+18 42 24	+23 16 37	+21 37 30	+14 15 22	+03 17 01	-08 15 59	-18 18 32	-23 13 41
16	-21 03 31	-12 33 40	-02 00 23	+09 53 03	+18 56 37	+23 19 14	+21 28 07	+13 56 41	+02 53 57	-08 38 13	-18 33 55	-23 16 53
17	-20 52 09	-12 12 53	-01 36 40	+10 14 22	+19 10 31	+23 21 26	+21 18 21	+13 37 46	+02 30 49	-09 00 19	-18 48 57	-23 19 37
18	-20 40 23	-11 51 54	-01 12 56	+10 35 31	+19 24 06	+23 23 13	+21 08 14	+13 18 39	+02 07 38	-09 22 17	-19 03 39	-23 21 53
19	-20 28 13	-11 30 45	-00 49 13	+10 56 29	+19 37 21	+23 24 36	+20 57 45	+12 59 19	+01 44 25	-09 44 07	-19 18 01	-23 23 40
20	-20 15 41	-11 09 24	-00 25 29	+11 17 17	+19 50 16	+23 25 34	+20 46 55	+12 39 46	+01 21 09	-10 05 48	-19 32 02	-23 24 60
21	-20 02 45	-10 47 53	-00 01 45	+11 37 53	+20 02 50	+23 26 07	+20 35 44	+12 20 02	+00 57 52	-10 27 21	-19 45 41	-23 25 51
22	-19 49 27	-10 26 12	+00 21 57	+11 58 18	+20 15 04	+23 26 15	+20 24 12	+12 00 06	+00 34 33	-10 48 44	-19 58 59	-23 26 14
23	-19 35 47	-10 04 21	+00 45 39	+12 18 31	+20 26 57	+23 25 58	+20 12 20	+11 39 -59	+00 11 13	-11 09 58	-20 11 55	-23 26 09
24	-19 21 45	-09 42 21	+01 09 19	+12 38 31	+20 38 29	+23 25 17	+20 00 08	+11 19 40	-00 12 08	-11 31 01	-20 24 29	-23 25 36
25	-19 07 21	-09 20 13	+01 32 57	+12 58 19	+20 49 39	+23 24 11	+19 47 35	+10 59 11	-00 35 30	-11 51 54	-20 36 40	-23 24 34
26	-18 52 37	-08 57 56	+01 56 32	+13 17 54	+21 00 28	+23 22 40	+19 34 43	+10 38 32	-00 58 51	-12 12 36	-20 48 28	-23 23 04
27	-18 37 32	-08 35 31	+02 20 05	+13 37 16	+21 10 55	+23 20 44	+19 21 32	+10 17 43	-01 22 13	-12 33 06	-20 59 54	-23 21 06
28	-18 22 06	-08 12 58	+02 43 35	+13 56 24	+21 21 01	+23 18 24	+19 08 01	+09 56 44	-01 45 34	-12 53 26	-21 10 55	-23 18 40
29	-18 06 21		+03 07 01	+14 15 19	+21 30 43	+23 15 39	+18 54 11	+09 35 35	-02 08 55	-13 13 33	-21 21 33	-23 15 46
30	-17 50 16		+03 30 24	+14 33 59	+21 40 04	+23 12 30	+18 40 03	+09 14 17	-02 32 14	-13 33 28	-21 31 46	-23 12 24
31	-17 33 52		+03 53 43		+21 49 02		+18 25 36	+08 52 50		-13 53 10		-23 08 34

Table 1: Declinations of the Sun. The sign "+" means that the Sun is towards the northern celestial hemisphere and the sign "–" that it is towards the southern hemisphere

According to Table 1 of declinations (and the Figure 5), on Friday, October 7, the declination D of the Sun is -5º 14' (of course we only consider 5º with the instruments used, it does not make sense to consider minutes).

October 7 is after the day of the equinox, then it is autumn, then in Figure 6 we can see that the height of the Sun on the horizon h plus the declination $|D|$ is equal to the colatitude $90-|L|$

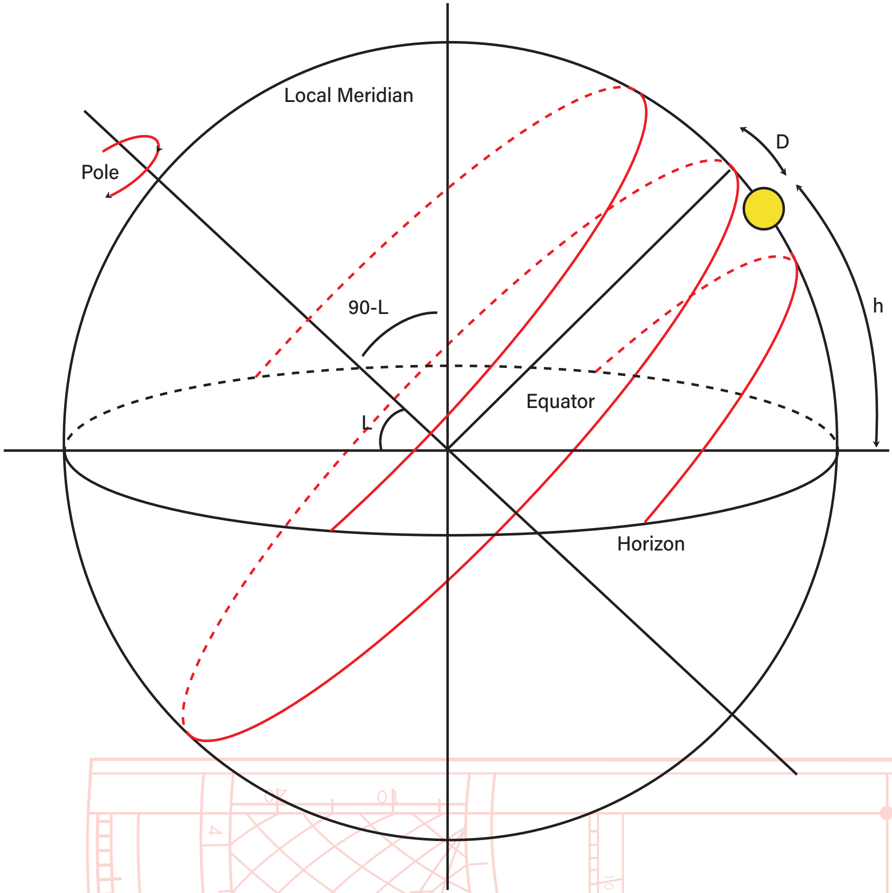


Fig. 5. The Sun moves in parallel below the equator and its height verifies $h+|D|=90-|L|$ (Credit: E. Viñuales).

$h+|D|= 90-|L|$
then the latitude $|L|= 90-h-|-5°|= 90-h-5°$

BUT THIS IS ONLY CORRECT WHEN THE SUN IS IN THE LOCAL MERIDIAN, THAT IS WHEN THE SUN CLOCK IS AT 12 SOLAR HOURS

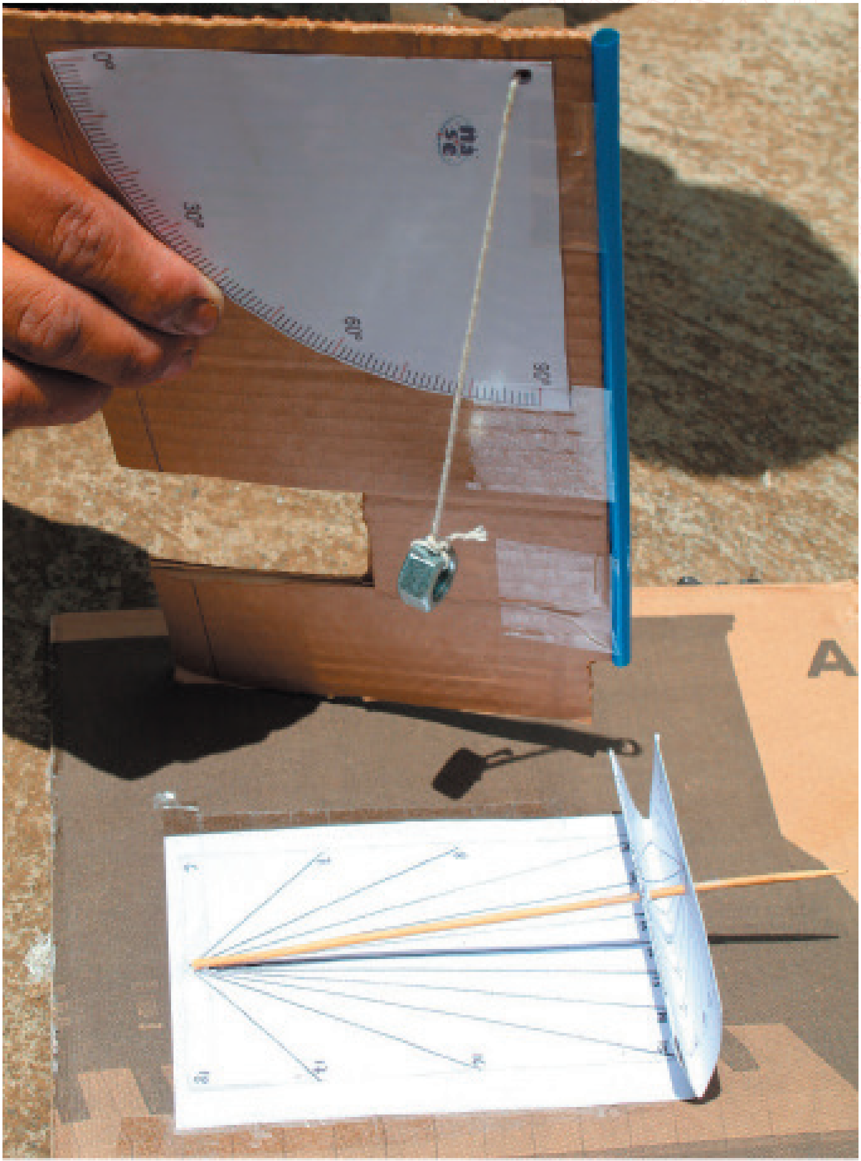


Fig. 6: Determined the height of the Sun exactly at solar noon, when the sun passes through the local meridian on the southern horizon (Guardabarranco Public School in collaboration with the National Autonomous University of Managua, Nicaragua) (Cr edit: L. Areas).

Attention because in Spain the official time of October 7 was 2 hours before solar time. that is to say that the solar time of 12 was 14 o'clock on our wristwatch or on our mobile. As the program of activities was going to take place from 9:30 a.m. to 1:00 p.m. Spanish official time, none of the groups could carry out the observation at the instant of solar noon, so the objective was to explain to the students the method used by the navigators and understand how to handle the height of the Sun, as well as the declination tabulated to be able to deduce the colatitude and then the Latitude.

Although it was already planned to explain the method without getting the precise value of Viladecans's latitude (41.5º) due to a time problem, the truth is that it was impossible to determine the height of the Sun at any instant. After months of drought; It was raining to sing to you all morning.

2. Quadrant Construction

The height of the Sun can be determined with a quadrant. To prepare a quadrant, it is enough to have a ruler and a protractor. Set a plumb line at the origin of angles and arrange as can be seen in Figure 7.

To make a "NASE pistol quadrant", it is only necessary to have a piece of cardboard as seen in Figure 8 with a handle to hold it. Glue a graduation or a graduated semicircle, fix a thread at the origin of the graduation with a weight at the end (to tighten the thread) and fix a straw, drinking straw or paper cylinder on top to be able to use it viewfinder (Figure 8).

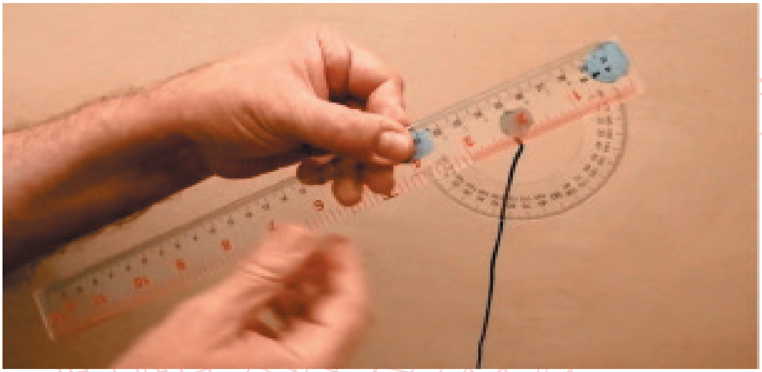


Fig. 7: Dial with ruler and protractor (Credit: RM. Ros).

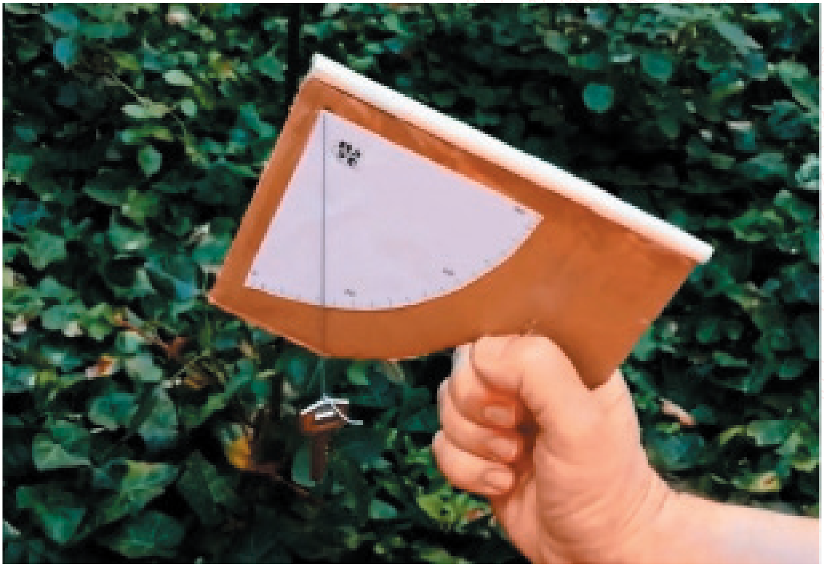


Fig. 8:: NASE pistol quadrant (Credit: RM. Ros).

Fig. 9: With a semicircle oriented towards the sun, we can obtain its height (1st Experimental Junior High School of Maroussi, Greece) (Credit: V. Petridou)

In either of the two cases, it is really easy for each student to prepare their own quadrant to take the necessary measurements (Figure 10) or sharpen their ingenuity and arrange a protractor so that it gives us the height of the Sun (Figure 11)

Fig. 10: Both quadrants are easily made as these students did in Romania (Tiberiu popoviciu Computer Science High School, Cluj, Romania). (Credit: C. Toma).

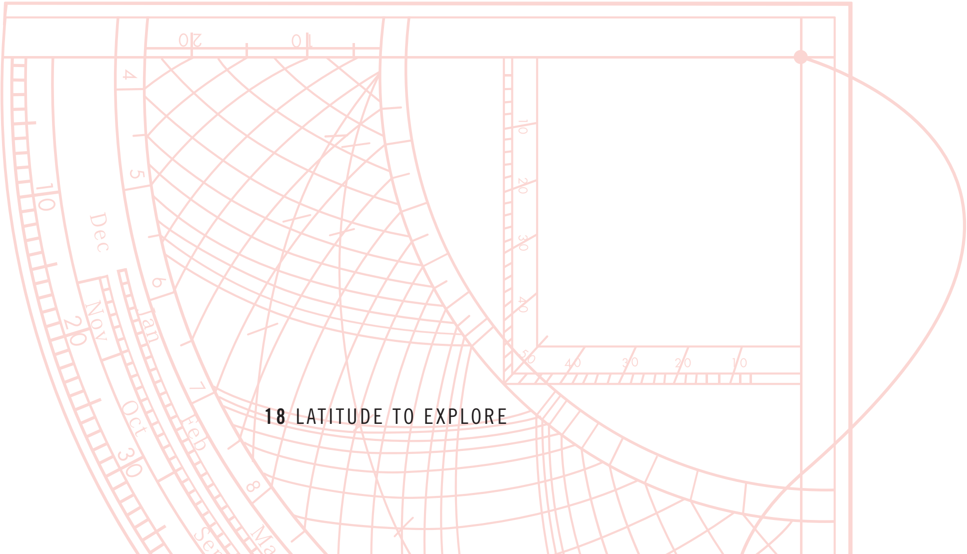


Fig. 11: Even primary school students can prepare the quadrant themselves. (Shahid Haghani Board Trustees School, Gilan-Keleshter, Iran) (Credit: H. KHezri).

Fig. 12: A group of teachers preparing the necessary materials to carry out the Latitude experiment (Ulaanbataar Planetarium, Mongolia) (Credit: T. Renchin).

Fig. 13: Future educators are also at a very appropriate stage to carry out the experiment. (UNCuyo Teacher Training School, Mendoza, Argentina) (Credit: B. García).

To determine the height of an object, you must aim and look through the straw or straw that acts as a viewer (Figures 14). The angle, which we read on the dial, gives us the height of the object above the horizon, since the plumb line is perpendicular to the horizon and the viewfinder is perpendicular to the 0 edge of the graduation

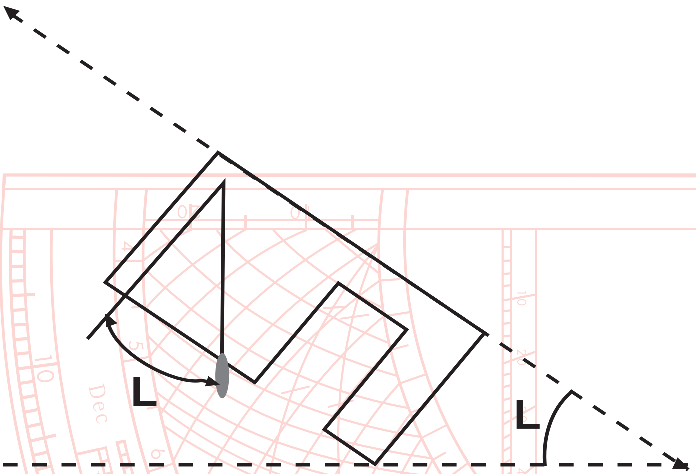


Fig. 14: The angle read on the quadrant matches the height of the object above the horizon. (Credit: RM. Ros).

Before making the observations, it is good to practice with the quadrant and learn to correctly read the angle obtained.

Fig. 15: Practicing with the dial to read the angle obtained. Terrestrial applications allow calculation of the height of a building or a mountain.
(CEG ALPASSA, Porto-Novo, Benin) (Credit: PA. Ahanhanzo).

If the object to be considered is the North Star, it is observed directly through the viewfinder. But if it is the Sun, it is dangerous to look directly at it and the observation must be by projection as seen in Figure 16.

As previously mentioned, to determine the height of the Sun and with it the local latitude, it is necessary to take the height of the Sun at solar noon (Figure 6), so it is good to have a sundial to take this height exactly when the clock marks the 12 of the Sun, that is to say when this star culminates when passing through the South passing (in the Northern Hemisphere) or the North (in the Southern Hemisphere). Next, we will not proceed to explain the construction of a sundial because this content can be easily found in many places. In any case, at the end of this text there are references to the construction of the sundial on the NASE website for those who wish to consult it.

3. Results Collection

Finally, once the quadrant is made, it is enough to make the observation and send the results of Table 2 to the project organizers

Place City Country	Day month	Hour	Solar declination	Latitude obtained using pole	Latitude obtained using sun	Latitude real

Table 2: Data collection and obtaining the Latitude of the place

Fig. 17: Students operating the self-made quadrant with an original and novel design (Ramygala Gymnasium in Lithuania) (Credit: P. Raugala and L. Žitkevičičč).

Fig. 18: Obtaining the height of the Sun in Iran (Khormoi Castle, Khormuj, Iran) (Credit: F. Salimi).

Fig. 19: Equatorial sundial with Chinese characters (Beijing Planetarium, China) (Credit: D. Chen).

Fig. 20: Greek students determined the height of the Sun in Athens (Junior-Senior Hing School in Chalandri) (Credit: K. Chrysanthakopoulou).

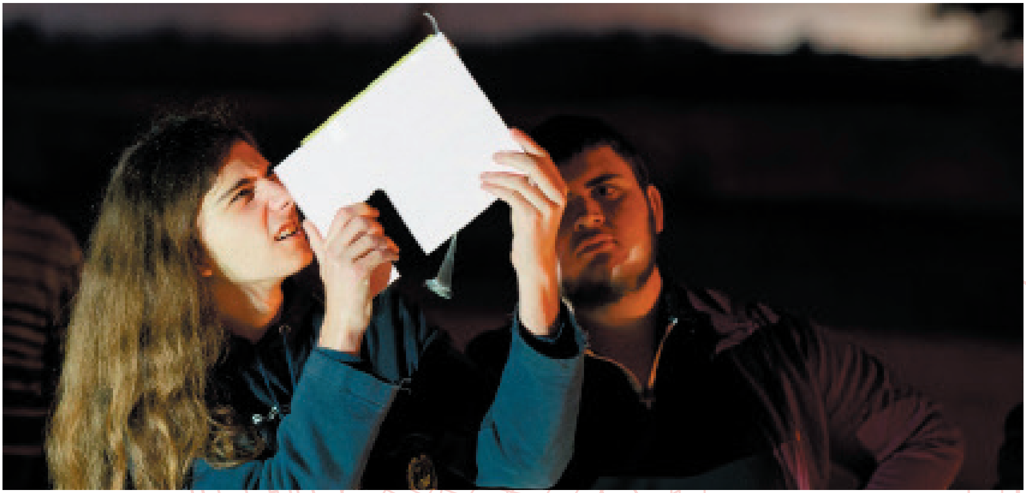


Fig. 21: Determining the height of the Polar (Lycée Paul Guerin, Niort, France) (Credit: F. Smanio and S. Al-Tai).

Fig. 22: Preparing the quadrant in "Sinthiou Garba School"(Matam Region, Senegal)) (Credit D.S. Mamadou).

Fig. 23: Determining the height of the Sun in Istanbul, Turkey. (Credit: M. Yečiltepe).

Fig. 24: Observing the height of the Sun in Porto Novo, Benin (Credit: PA Ahanhanzo).

4. Famous routes and astronomy

The method for determining latitude allowed a great advance in navigation, being able to develop it beyond the coastal navigation of previous centuries. With this, great communication routes were developed for all humanity.

It is good to mention that astronomy has also been present in other contexts related to long routes and large displacements with contributions related to the travellers' orientation.

There are several great routes to consider, in addition to those already mentioned, for example:
The Silk Road
The Road to Santiago
The Way of the Inka.

As well as those designed by the great navigators of the 15th and 16th centuries, which we can summarise as follows:
The Voyages of Columbus
Around the World of Magellan and Elcano.

In the sections that follow, minimum content is developed on these routes by land or sea.

LTHE SILK ROUTE: Medieval observatories and Persian Chartaquis.

This road corresponds to the routes that connect China with most of the Asian continent Mongolia, Pakistan, Persia, Tajikistan, Uzbekistan, Turkey, the European Mediterranean and the eastern coast of Africa. Its name is due to the silk that circulated through it and whose production secret only the Chinese knew.

Fig. 25: The Silk Road that linked China with Europe starting from Xian through Kashgar, Samarkand, the ancient Hecatompylos at the end of the Caspian Sea to Istanbul (Credit: L. Torres).

The Chinese Emperor Wu of the Han dynasty (1st century BC) promoted contact with other civilizations and to cross the steppes of Central Asia they followed the areas with water, to be able to cross the deserts. The route has many variants not specifically drawn by astro-nomical criteria.

Various wars took place intermittently between the Roman Empire and the Persian Em-pire from 53 B.C. until 217 A.D., affecting the silk route and its security, and also giving rise to a transfer of information between the two empires. For example, the Romans take their model from the Chartaquis (part of the Persian fire temples) which can be located in many points with clear horizons in the territories of the Persian Empire. In addition to the religious use, Chartaquis were signs on the road that were built and they were solar ob-servatories. These constructions somehow synchronise with the solar trajectory with a dome supported by 4 columns oriented in such a way that the direction of the summer and winter solstices determine the position of the 4 columns (Figures 26 and 27).

Fig. 26: The Chartaqi are very well oriented. They are structures consisting of four pillars oriented according to the cardinal points, and four arches that support a dome (Credit Hosein).

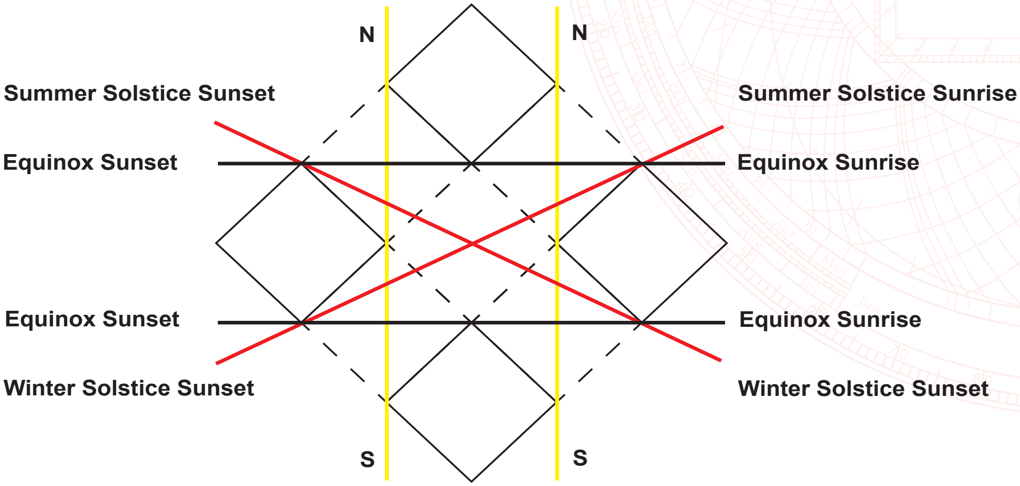


Fig. 27: The plan of the chartaqi Khaneh-i-Div helps to understand the architectural concept because it is located on a clear horizon and the alignment of the sunrise on the summer solstice corresponds to the sunset on the winter solstice, just as the alignment of the sunset on the summer solstice coincides with the sunrise on the winter solstice (Credit: RM. Ros).

These constructions can still be seen among others countries in Austria, Spain and Italy (areas of the former Roman Empire).

With the fall of the Western Roman Empire in the fifth century and the establishment of feudalism in Europe, Europe became disconnected from the Asian trade routes.

During the 9th and 10th centuries, Persian astronomers built Ptolemaic instruments and astrolabes. The use of astrolabes was very important to travel the silk road. The silk road is located between the terrestrial parallels of 33º and 43º. Thus, a medieval traveller who circulated, for example, from Damascus to Baghdad should move in a latitude close to 33º, with an astrolabe he can monitor the height of the pole star night after night and thus continue on his way, so it is almost certain that they would use that instrument to be able to travel.

Furthermore, in the 11th, 12th and 13th centuries various institutions built astronomical observatories (Malikshah, Maragha and Gaocheng) along the silk route. All of them en-dowed with enormous instruments and large libraries and on many occasions related to madrasas.

Fig. 28: The Arch of Janus is the only quadriform arch preserved in Rome. The arch originally supported a dome, which was removed in the 19th century, when it was mistaken for a medieval addition (Credit: A. Covelli).

Fig. 29: A coin of Emperor Nero with his arch on the reverse, which also had a chariot on top (Credit: ebay-numismatica).

With the Mongol expansion from 1207 to 1360, the Silk Road was reactivated again thanks to the new political stability. During the Mongol Empire, a great trade between East and West developed, both in the matter of silk and in the trade of the species so necessary for the preservation of food at that time. In addition to a constant flow of cultural exchange and of course, astronomy was present and the remains of multiple medieval observatories strategically distributed for travellers are still displayed. Around the same time, the Vene-tian, Marco Polo, travelled the route to China, and his travel book is well known.

THE ROAD TO SANTIAGO: Milky Way to guide

Santiago de Compostela is known throughout the world because it is believed that the tomb of the Apostle Santiago is located there. The three most important cities of Christianity are Rome, Jerusalem and Santiago de Compostela.

Since the 9th century, pilgrims from many European countries have walked there along the so-called Camino de Santiago. This was a very important way of communication in Europe during the Middle Ages. The truth is that this European pilgrimage route was a source of cultural development and transfer of knowledge, as can be detected in the religious constructions along the way. The Romanesque influences originating in Italy reach Santiago de Compostela along the Cantabrian coast, practically in the Roman "Finisterre".

Fig. 30: From all over Europe you could get to Santiago de Compostela on foot. (Crédit: L. Torres).

Fig. 31: There are several roads to Santiago de Compostela but the main one is the French Way that enters Spain through Roncesvalles (Navarra) or Somport (Aragon), both branches coming together in the small town of Puente la Reina. (Credit: L. Torres).

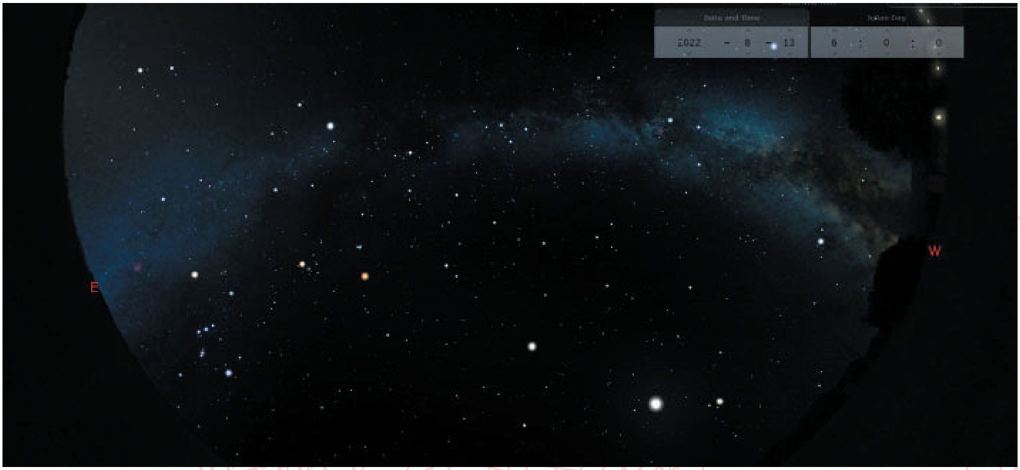


Fig. 32: The layout of the Milky Way in summer is in the East-West direction, as seen in this simulation (Stellarium), that is, in the direction of the Cantabrian coast (Credit: A. Docobo).

Fig. 33: The pilgrims followed the direction of the Milky Way (Credit: Turismo de Galicia)

It coincides that in the summer months the Cantabrian coast aligns with the Milky Way at night, so the pilgrims followed this path indicated by the stars during nights with good weather, which were surely the ones chosen by the pilgrims of antiquity as they are now for the current ones, since doing the path in the winter season, raining and always cloudy, was not, nor is it, advisable. Some believe they see in the name of the place where the Apostle Santiago is a corruption of the word "campo de estrelas (star field)".

The Camino is currently a sociological event of the first order. More than 300,000 people per year come to Santiago de Compostela to pray before the tomb of the Apostle Santiago in the Cathedral.

THE PATH OF THE INKA: Astronomical Alignments.

In Quechua language, Qhapac Ñan means "Way of the Mighty". Known as the "Camino del Inka", it is a road network built on the slopes of the Andes and connected territories that today belong to six countries. Its splendid extension was completed by the Inca people under the Tahuantinsuyo Empire in its period of greatest expansion, between the 15th and 16th centuries. This road was part of the road network whose main function was to connect the centres of production, administration and ceremonies located in the different territories conquered by the power of this empire.

Fig. 34: Map of the Inca trail (Credit: Wikipedia).

Fig. 35: Inka Trail near Machu Picchu (Credit Wikipedia)

It has a span of more than 23 thousand kilometres, traced from the southwest of Colombia to the centre-west of Argentina. It crosses Ecuador, Peru, Bolivia, Chile and Argentina. It was a route that required the construction of bridges, tunnels, pavements, forts, warehouses, and checkpoints.

The road had a fundamental geopolitical importance, it was key to the existence of the Inca Empire since it allowed the incorporation of various peoples and ethnic groups. It is said that the Inka Empire never suffered from famine, and this was precisely the consequence of the existence of this great communication network, through which resources and products circulated to the entire population. On one side of the road were the cultivation terraces (which have allowed us to discover sophisticated hydraulic engineering for irrigation), and the grain cellars.

Fig. 36: Saywas in the Atacama desert showing astronomical alignments. Sunrise on June 21, 2015, marking the winter solstice. The photo is taken from the two central saywas in a west-east direction (Credit: S. del Campo).

In the Atacama Desert, the saywas or stone milestones that are located on both sides of the road were found. Some authors suggested that they could be distance measurement systems according to what was indicated by Spanish and indigenous sources of the time. However, the distribution of these structures on the road seemed to be arbitrary, there is no regularity in the location or the distance that separated these marks.

Other authors concluded that this type of marker, rather than "measuring" in a contemporary Western sense, would be accounting for a demarcation of political boundaries and territorial rights, even on the Inka's own path. The orientation of the saywas with respect to the Inka path, the differences between them, the quantity, location and distances that they presented from each other in the same place, opened the possibility that they were astronomical alignments: the Inka saywas were closely associated to solar worship and the measurement of calendrical time. The term saywa is used to name them since in the old Quechua and Aymara vocabularies it is defined as "landmark" or "boundary" of Inka lands and roads, but it is also synonymous with ticnu "the zenith or point of the middle

Fig. 37: The basalt piece found in the east saywa of Tocomar (Credit: M. Núñez). Fig. 38: 16th century illustration of what was probably a saywa. Its resemblance to the basalt piece can be appreciated. (Credit: Fray Martín de Murúa).

of the sky". On the other hand, "sayba" is the term used in the 16th century to refer to the astronomical columns of Cusco that indicated solstices, equinoxes and the seasons.

The Inka civilization, one of the most important and representative in South America, is a true example of cultural, linguistic and organizational diversity among the countries of the Andean region of America.

THE VOYAGES OF CHRISTOPHER COLUMBUS: A lunar eclipse

In 1492 Columbus sailed to the West with the purpose of reaching the Indies by circumnavigating the world; After stumbling and discovering the American continent, he departed on his last voyage in 1502 with the aim of finding a maritime strait to Asia. At that time, it was essential to find a new route to reach the spices, since they served to preserve food and were more valued than gold.

Columbus managed to reach America (Figure 39) by sailing in the sea without references and trying to stay in the same parallel. To do this, he did not have complicated instruments, only a quadrant, and he determined the height of the Pole star in order to follow the same parallel. On the first trip, he moved between the parallels of the Canary Islands (29° N) and San Salvador (25°N) and the height of the North pole was used to determine their latitude in the non-equatorial zone. For this last zone, it was necessary to determine the latitude using the height of the sun.

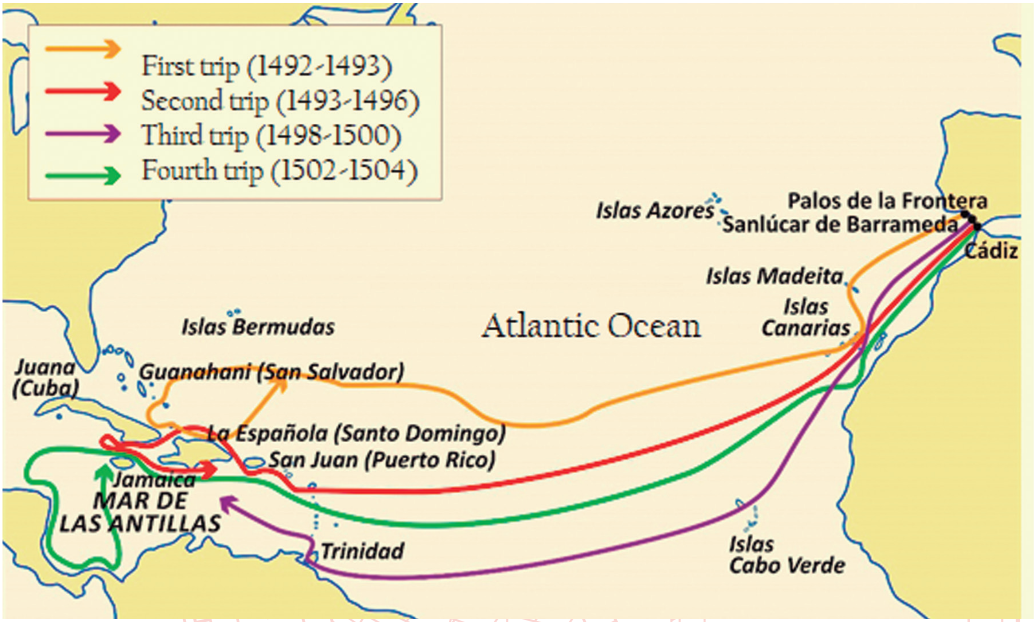
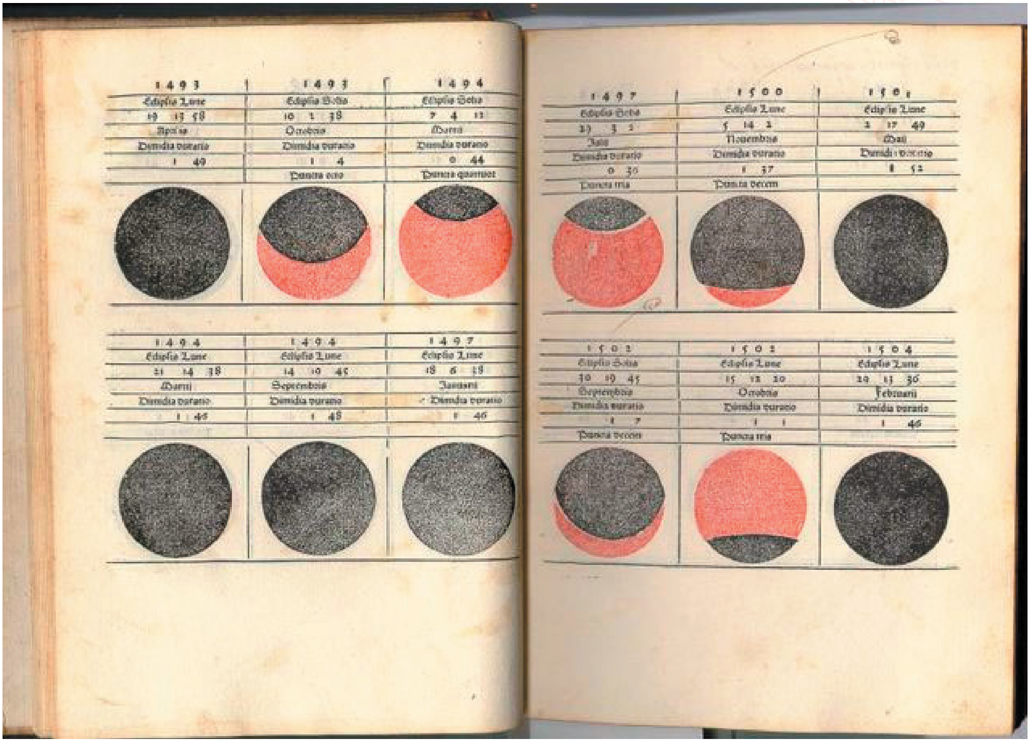


Fig. 39:. The four voyages of Columbus. They cross the Atlantic Ocean. On his first voyage Columbus moved be-tween the parallels of the Canary Islands 29ºN and San Salvador 25ºN (Credit: L. Torres)

In particular, the four voyages of Christopher Columbus were already developed using the determination of latitude with the help of the height of the pole star at night and the declination and height of the Sun during the day. In those times when it was cloudy, the situation was reduced to the use of the compass (the so-called dizzy needle) that indicat-ed the magnetic north and not the geographic north, which led to deep headaches, such as those described by Columbus in the logbook in which he observes discrepancies be-tween the direction of the navigation needle and the position of the Pole Star. In fact, he was the first observer to detail these variations that he does not know how to explain. Fernando de Magallanes and Juan Sebastián Elcano also detected these discrepancies and they will be dealt with later in this same publication.



1493	1493	1494
Eclipsis Lune	Eclipsis Solis	Eclipsis Solis
19 13 58	10 1 38	7 4 11
Aprilis	Octobris	Marcii
Dimidia duratio	Dimidia duratio	Dimidia duratio
1 49	1 4	0 44
	Puncta octo	Puncta quatuor

1494	1494	1497
Eclipsis Lune	Eclipsis Lune	Eclipsis Lune
21 14 38	14 10 45	18 6 18
Marcii	Septembris	Januarii
Dimidia duratio	Dimidia duratio	Dimidia duratio
1 46	1 48	1 46

1497	1500	1501
Eclipsis Solis	Eclipsis Lune	Eclipsis Lune
29 3 2	5 14 2	2 17 49
Julii	Novembris	Maii
Dimidia duratio	Dimidia duratio	Dimidia duratio
0 30	1 37	1 52
Puncta tria	Puncta decem	

1502	1502	1504
Eclipsis Solis	Eclipsis Lune	Eclipsis Lune
30 19 45	15 12 20	29 13 30
Septembris	Octobris	Februarii
Dimidia duratio	Dimidia duratio	Dimidia duratio
1 7	1 1	1 46
Puncta decem	Puncta tria	

Fig. 40: Pages of the Regiomontano almanac where the data of the eclipse of February 29, 1504 are detailed."Regiomontano", which comes from the Latin translation of the name of the German city where its author was born (Knigsberg and which means Royal Mountain). The eclipse of February 29, 1504 is in the lower right corner. (Credit: Glasgow University)

It is well known that Columbus had some astronomical knowledge that he used in his travels. As a curiosity, it can be said that during his fourth and last trip, the eclipse of Feb-ruary 29, 1504 saved him from perishing due to lack of resources and getting food and water from the natives of the island of Jamaica.

A total lunar eclipse begins with a partial eclipse in which the Moon appears partially dark, then totality begins in which it looks totally dark for a moment but one quickly no-tices the reddish hue of the Moon characteristic of this type of eclipse, because the sun-light does not reach the satellite directly but is filtered by the Earth's atmosphere where it is scattered and the red colour continues without deviating, hitting and then reflecting off the lunar surface.

Columbus knew the sky and was guided by the constellations. On his voyages he took with him the Regiomontano almanac (made by Johann Müller 1436-1476; Figure 40) which documented, among other things, the eclipse of February 29, 1504. Columbus knew what time the eclipse began and that the Moon would become red. That eclipse of 1504 had a special characteristic: the lunar eclipse began when the Moon was still below the horizon, so that when it appeared in the sky it would already be red.

So, Columbus knew that this would not be a normal eclipse, but that the satellite would come out red as blood, and he used it to get food. He called the indigenous caciques and told them that God was angry with them and that that night signs of it would be shown in the sky, and the result of this deception saved the lives of the expedition members.

THE VOYAGE OF MAGELLAN AND ELCANO: the sky of the Southern hemisphere

In the first circumnavigation of the world (Figure 41), Magellan and Elcano must cross several oceans and navigate through the equatorial zone where they cannot see the pole star. On this trip that lasted three years (September 20, 1519 to September 6, 1522) they must manage their astronomical knowledge. The quadrant and the tables of solar declinations were their instruments to determine the latitude by observing the height of the Sun. In this project for UNESCO's International Day of Light, the participants have been tasked to determine their latitude using the same method as the ancient sailors who went around the world for the first time in the 16th century.

Undoubtedly Magellan had important astronomical knowledge and it is known that in 1505 on a trip prior to the circumnavigation and under the auspices of the King of Portugal, he already named the constellation of the Southern Cross, which is precisely the one used in the southern hemisphere to denote the South celestial pole (since there is no star like the polar one that points to the North pole).

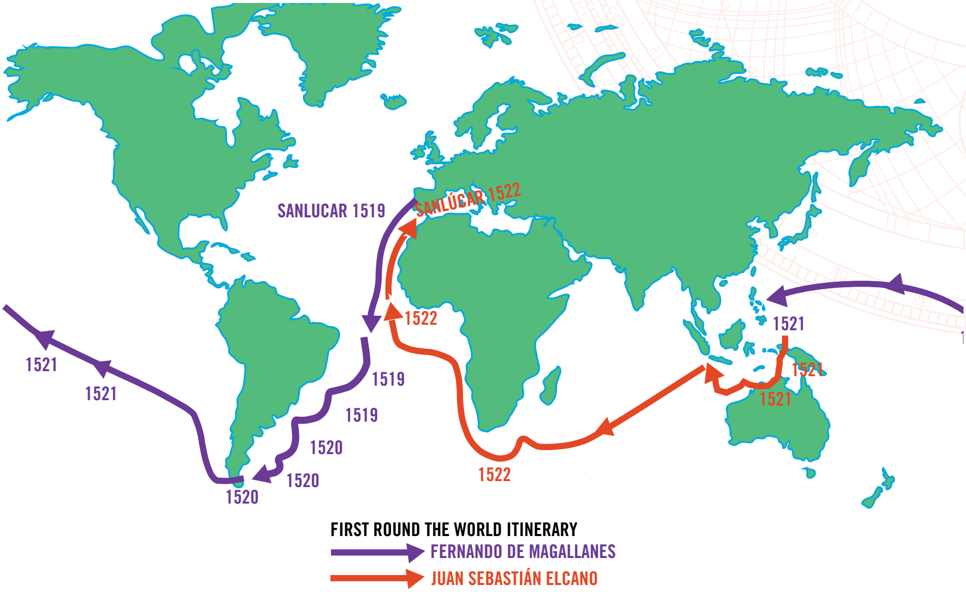


Fig. 41: The first circumnavigation of the world by Magellan and Elcano. In addition to the Atlantic Ocean and the Indian Ocean, they must cross the Pacific Ocean between the parallels of the Straits of Magellan (53º S) and the parallel of the Philippines (14ºN) (Credit: L. Torres).

In Europe, Magellan was the first to reveal the nebula of the Large Magellanic Cloud, since he observed it during his trip between 1519 and 1522 and it was documented by Antonio Pigafetta, rapporteur of the expedition. However, its current name became popular much later.

What is quite certain is that both Magellanic Clouds were known to the peoples of the Middle East. In 964, the Persian astronomer Abd Al-Rahman Al Sufi names them as Al Bakr (White Ox) noting that it is possible to observe them from latitude 12ºN in Baghdad, but evidently they were invisible and unknown in Europe.

Although Magellan and Elcano did not discover them, they became aware of their existence while navigating the South Seas, and during this voyage they noticed that certain constellations disappeared from the sky and new ones arose instead. The southern firmament had other stars and constellations unknown in Europe. Thus, of the 88 constellations defined by the IAU, a good number of them appear in the 16th and 17th centuries, after the great exploration voyages. Consequently, we can classify the constellations into two large groups. Ancient constellations usually have their origin in Greek mythology: Leo, Scorpius, Taurus, Andromeda, Aquarius, Aquila, Ara, Aries, Auriga, Bootes, Cancer, Canis Major, Canis Minor, Capricornus, Cassiopeia, Centaurus, Cepheus, Cetus, Corona Australis, Corona Borealis, Corvus, Crater, Cygnus, Delphinus, Draco, Equuleus, Eridanus, Gemini, Hercules, Hydra, Lepus, Libra, Lupus, Lyra, Ophiuchus, Orion, Pegasus, Perseus, Pisces, Pisces Austrinus, Sagitta, Sagittarius, Serpens, Triangulum, Ursa Major, Ursa Minor, Virgo. And the constellations discovered during the 16th and 17th centuries are named after some instruments and machines used in those centuries, as well as animals native to America and even a tribute to the "American Indians": Crux, Triangulum Australe, Coma Berenices, Columba, Apus, Chamaeleon, Dorado, Grus, Hydrus, Indus, Musca, Pavo, Phoenix, Tucana, Volans, Camelopardalis, Monoceros, Canes Venatici, Lacerta, Leo Minor, Lynx, Scutum, Sextans, Vulpecula, Antlia, Caelum, Carina, Circinus, Fornax, Horologium, Mensa, Microscopium, Norma, Octans, Pictor, Puppis, Pyxis, Reticulum, Sculptor, Telescopium and Vela.

The constellations of antiquity were described by Claudius Ptolemy and the modern con-stellations were named much later. One of the astronomers who assigned names to the constellations in the southern hemisphere was the Flemish astronomer Petrus Plancius (1552-1622) who is known for having introduced the Mercator projection method to navi-gational maps. Many others owe their name to Johann Bayer who in 1603 published the first star atlas of the entire celestial sphere, Uranometry. Abbot Nicolas Louis de Lacaille named fourteen other constellations. This French astronomer catalogued almost ten thou-sand stars and more than forty astronomical objects. The rest of the modern constellations owe their name to Johannes Hevelius (1611 – 1687), a Polish astronomer recognized as the author of lunar topography.

The 18th century Nicolas de Lacaille went to the Cape of Good Hope to study a group of astronomical objects from the southern hemisphere. But the first to study the Magellanic Clouds in detail was John Herschel who travelled to Cape Town between 1834 and 1838 to observe them among others.

The Magellanic Clouds are two satellite galaxies of ours, the Milky Way. The Large Magel-lanic Cloud is about 8º in angular size, that is, about 16 times the diameter of the Moon with the naked eye. It is a dwarf galaxy located 160,000 light years from the Milky Way, but as Magellan described it as a cloud, it continues with this nomenclature. The Small Magellanic Cloud is an irregular dwarf galaxy that is almost 200,000 light-years away, but despite this it is perfectly visible to the naked eye near the Large Magellanic Cloud, occu-pying an angular extension of about three degrees in the sky, about six times the size of the Moon, so it also looks big. According to recent investigations it is believed to be an elliptical galaxy distorted when passing close to the Milky Way.

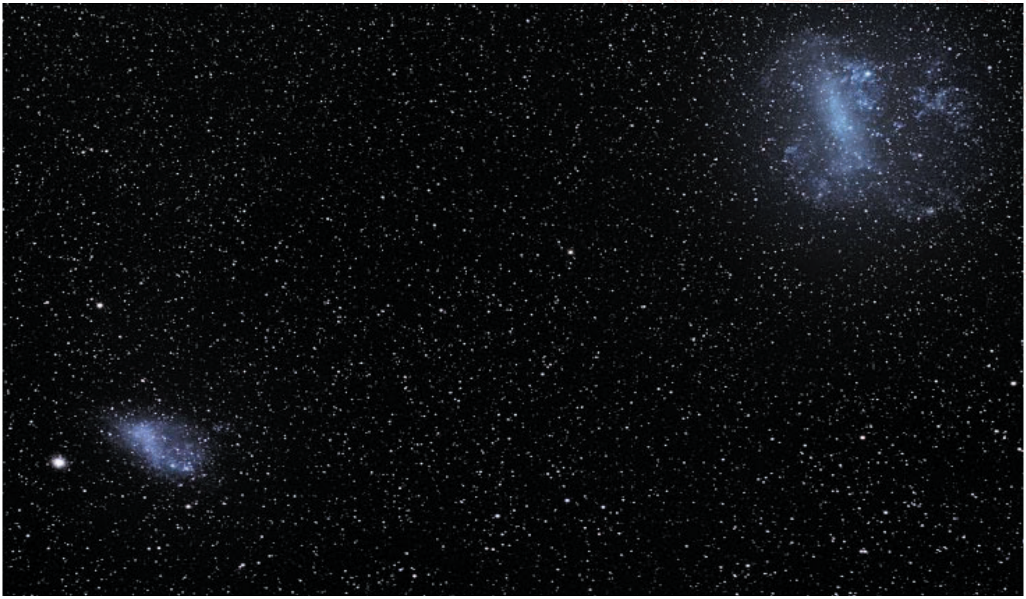


Fig. 42: The Magellanic Clouds (Credit: ESO)

5. The Magnetic Compass Drift

Today the positioning at the middle of the ocean, where there are no land references, is not a problem, as we have Global Navigation Satellite Systems (GNSS), such as GPS. But this was not always the case.

Until 1492, when Christopher Columbus ventured out to sea, crossing the uncertain Atlantic and discovering America, the problem of positioning at sea was not really important. Until then, sailing close to the coast, or crossing the Mediterranean in Europe, did not involve long periods of time far away from land and, therefore, positioning at sea was not really a serious problem.

The navigator looked at the stars at night and the position of the Sun during the day, and if it was dark and cloudy, he lets himself be guided by a magnetic compass.

This rudimentary instrument was discovered in China between the 2nd centuries BC and 1 AD, although it was only used for geomancy, also known as divination, which interpreted geographical lines or alignments, and it is not until the early eleventh century when it is used as a navigation instrument. In Europe, the first known magnetic compass used for maritime navigation is mentioned in 1187 by Alexander Neckham. His writings describe a needle carried on board, which allowed a course to be followed, even when the Pole Star was covered by clouds.

The magnetic compass was a fundamental instrument on board to maintain the course and estimate the position of the ship (knowing the course and the navigated distance) with maximum possible precision. It should be noted that the problem of longitude determination will not be solved until the middle of the eighteen century, thanks to Harrison's marine chronometer.

The writings of the first circumnavigation of the world of Juan Sebastián de Elcano (1519-1522) relate a strange phenomenon observed by Magellan while crossing the Atlantic heading towards the West: The compass seemed to drift to the northeast.

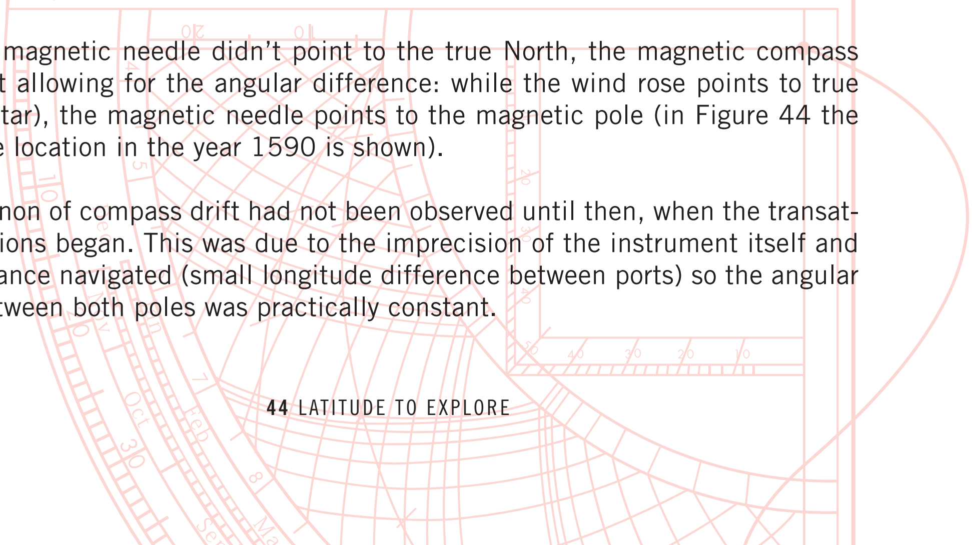
But what was the reason for such a strange phenomenon?

Today we know that this phenomenon is due to magnetic declination, which is nothing more than the angle between the geographic North and the magnetic North poles.

Geographic North is defined by the Pole Star or by the meridian (the meridian of the Sun at 12:00 local time), when the Sun reaches its maximum elevation. Looking at the sky for a long time at night, you can see how the stars revolve around the Pole Star, which remains fixed. That fixed point is where the terrestrial axis of rotation cuts the sky and, therefore, the celestial Pole.

Although the magnetic needle didn't point to the true North, the magnetic compass could be built allowing for the angular difference: while the wind rose points to true north (Polar star), the magnetic needle points to the magnetic pole (in Figure 44 the magnetic pole location in the year 1590 is shown).

The phenomenon of compass drift had not been observed until then, when the transatlantic navigations began. This was due to the imprecision of the instrument itself and the short distance navigated (small longitude difference between ports) so the angular difference between both poles was practically constant.



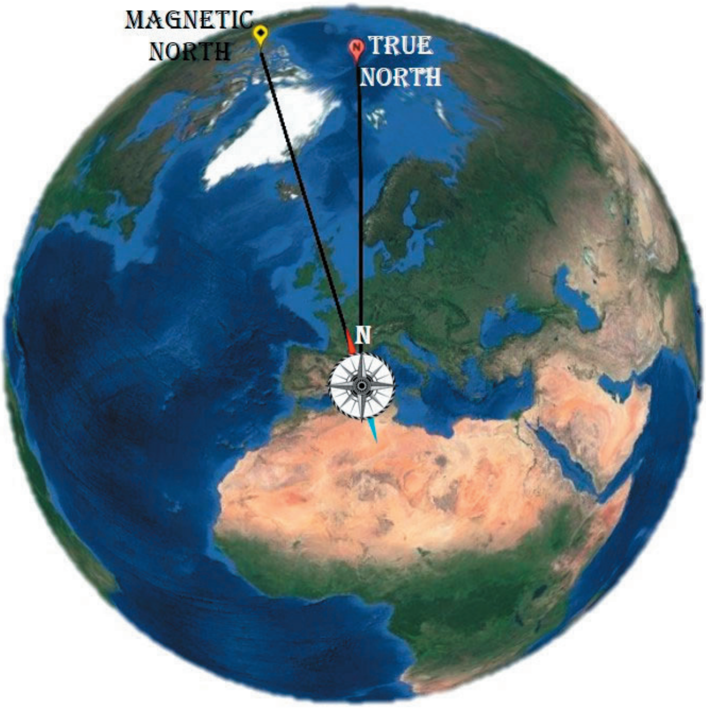


Fig. 43: Compass on the magnetic needle (Credit: A. Pazos).

So, why did Magellan observe the drift of the compass? And why did it drift northeast?

When the Columbus and Magellan expeditions departed to venture into the Atlantic, they headed West. At that time, the magnetic pole was located in northern Canada (although they didn't know it) and, therefore, the ship was approaching to the magnetic pole meridian while sailing West.

Although when we draw the world over a plane map, the Earth appears deformed (especially the polar areas) and the angles are not preserved. Let's see how the magnetic compass drifts to the East of the Polar star as we sail West.

To do this, let's draw the route of the Magellan expedition and the first circumnavigation of the globe of Juan Sebastián de Elcano over the map made by Diego Ribero, cosmographer of the Royal House of Contracting of Seville, in 1529.

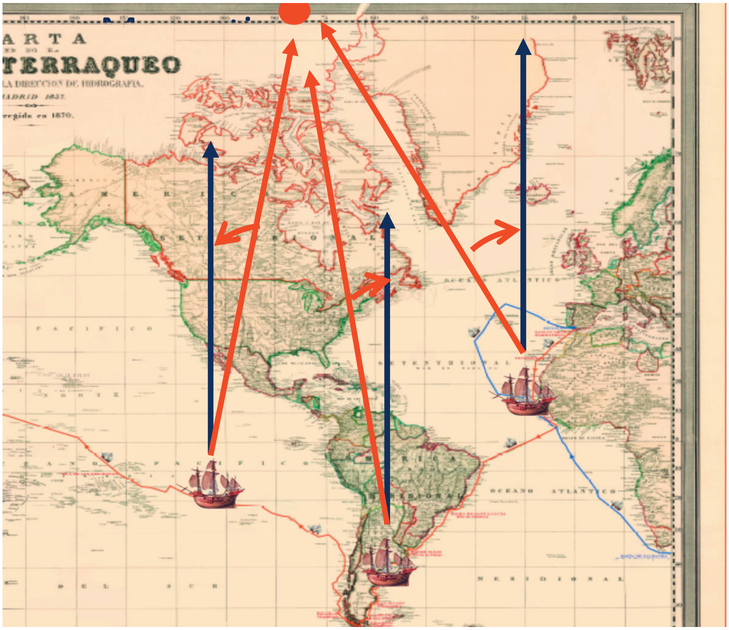
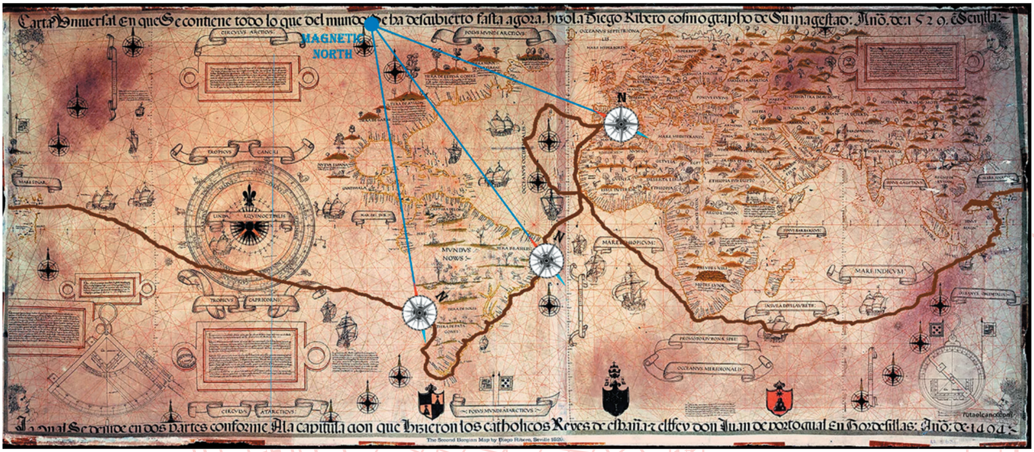


Fig. 44: The magnetic pole is represented by the red dot, and the direction of the geographic pole is given by the direction of the perpendicular meridian. When sailing West, the angle between the two varies. (Credit: A. Pazos)



FFig. 45: Ribero map (1529) with the first circumnavigation of the globe and the drift of the magnetic compass. (Credit: A. Pazos)

In Figure 45, we can appreciate how the compass with a magnet attached (as in Figure 44) orients its magnetic needle towards the magnetic pole and how the north of the attached wind rose drifts eastward as we sail west. It should be noted that, in this projection, the true North (Polar star) is always in the vertical line of the map.

Currently, the angle, on the horizontal plane, formed by magnetic north and geographic or true north is called the magnetic declination. The magnetic declination, in addition to varying with the years, varies according to the place where we are. For this reason, in the nautical charts its value and its annual increase or decrease are given.

6. Determination of Local Latitude in Viladecans in person

In the project of the experiment on the determination of Latitude using the solar declination 2021-2022, 22 countries have participated: Argentina, Benin, Bulgaria, China, France, Greece, Guatemala, Indonesia, Iran, Italy, Lithuania, Mongolia, Philippines, Paraguay, Portugal, Romania, Senegal, Spain, Tanzania, Togo, Turkey and the USA from 4 continents distributed in all latitudes. Reports of 150 works carried out in primary and secondary schools and centres have been received, as well as by some universities, planetariums and observatories. It is not possible to calculate the number of students involved, but due to the better COVID situation in all countries, their number has increased significantly.

The results received are displayed on the NASE website:
https://www.naseprogram.org/iau-unesco-projects/latitude_traveling-_navigate/

The project was scheduled to close in person during the final of Science in Action (Science on Stage Spain) in Viladecans, near Barcelona on October 7, 8 and 9. The organization had planned to place a set of tents in different parts of the town to receive the visit of thousands of schoolchildren who were expected to carry out the activity with the advice of 12 groups of foreign teachers who would explain the process to follow and offer students the option to calculate their own results. The truth is that although the situation of drought due to climate change, and the fact that at the beginning of October the situation is usually very sunny, the truth is that on October 7, scheduled for this public activity, it was raining all morning with intensity and non-stop for the entire time planned to carry it out.

Consequently, there was no other possibility than to group the 12 planned information points and reorganize them into 3 centres that offered their premises to be able to carry out "a simulation" of the activity using the flashlight of a mobile to simulate

Fig. 46: Teachers from Paraguay and the United States preparing the materials for observation, even though it was raining (Credit: J. de Vera).

Fig. 47: Simulating the Sun with a mobile flashlight while it was raining heavily (Credit: J. de Vera).

the Sun and use sundials and quadrants simultaneously. 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.

Teachers from the countries that participated in this event (France, Greece, Italy, Lithuania, Paraguay, Philippines and Romania Spain, the United States) had the opportunity to participate in person in the online event scheduled for October 8th, in addition to show and share their materials with the other classmates and enjoy the Science in Action fair that was developed not simultaneously with the NASE project.

Fig. 48: On the portico of the Atrium Theatre, the team of teachers from the Philippines with the students waiting for transport to a drier place to work (Credit: J. de Vera).

More than 500 students from Viladecans enrolled in their educational centres (Escola GOAR, Escola Montserratina, Escola Teide, I.E.S Olímpia, I.E.S. Torre Rola, I.E.S. Josefina Castellví, Escola Àngela Roca, I.E.S. Sales). Every 15 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 Friday, October 7, although it did not stop raining for a moment.

To avoid getting wet, the 12 groups of teachers were arranged in 4 places whose locations were:

- Centre 1: Casal de la Montserratina (Figures 51, 55, 56 and 58) with the 3 teaching groups from Romania, France and Lithuania.
- Centre 2: Lobby of the Viladecans Town Hall (Figures 52, 53 and 54) with teachers from Mongolia, Romania and Spain.
- Centre 3: Olimpia Secondary School (Figures 50 and 59) with teachers from Italy, Greece and Romania.
- Centre 4: Josefina Castellví Secondary School / Escola Enxaneta (Figures 49 and 57) with teachers from the Philippines, Paraguay and the USA.

Fig. 49: In the gym of the Josefina Castellví Institute, a part of the teams from the United States, Paraguay and the Philippines (Credit RM. Ros).

In all cases, the students were taught to handle the sundial and the dial, although since there was no Sun, flashlights were used to simulate the Sun or some point on the wall was used to determine its height with the quadrant. There was also time to explain how the instruments were built (the cutting out the materials that could be found on the NASE website).

Fig. 50: Olímpia Institute with the teams from Italy, Greece and Romania (Credit. E. Viñuales).

Fig. 51: Casal Montserratina with the Romanian teams in the centre, France in the background and Lithuania on the left (Credit: RM Ros).

Fig. 52: Lobby of the Viladecans Town Hall where the teams from Mongolia, Romania and Spain were installed (Credit RM. Ros)

Fig. 53: The teacher from Mongolia showing how to use the sundial to know when it is solar noon to determine latitude (Credit: RM Ros). Fig. 54. The professor from Romania explaining how the quadrant is used to determine the height of the Sun at solar noon (Credit: RM Ros).

Fig. 55: Romanian professors and NASE members explaining the concept of latitude and how to deduce it from the solar path (Credit R.M. Ros).

Fig. 56: The French team members of the CLEA (Comité de Liaison Enseignants et Astronomers) and NASE explain the construction and use of the equatorial sundial based on understanding the trajectory of the Sun. (Credit. RM Ros).

Fig. 57: Rehearsing the use of the quadrant with the professor of the Astronomical Observatory of the University of Asunción, Paraguay and who is also a member of NASE (Credit: R M. Ros).

Fig. 58: Teachers from Lithuania introducing themselves to the essential concepts to get the local latitude (Credit: RM Ros).

Fig. 59. Using the marine quadrant with the Italian teacher to determine the local latitude (Credit: RM Ros).

Fig. 60: Professor from Romania and member of NASE, preparing a simplified version of the quadrant with a protractor and a ruler (Credit: P. Chis).

7. End of "Latitude to travel and navigate"

The online session held on October 8, 2022 was streamed worldwide, recorded, and can be viewed on the NASE YouTube channel, at the following link:
https://youtu.be/bKdpxBE9ofc

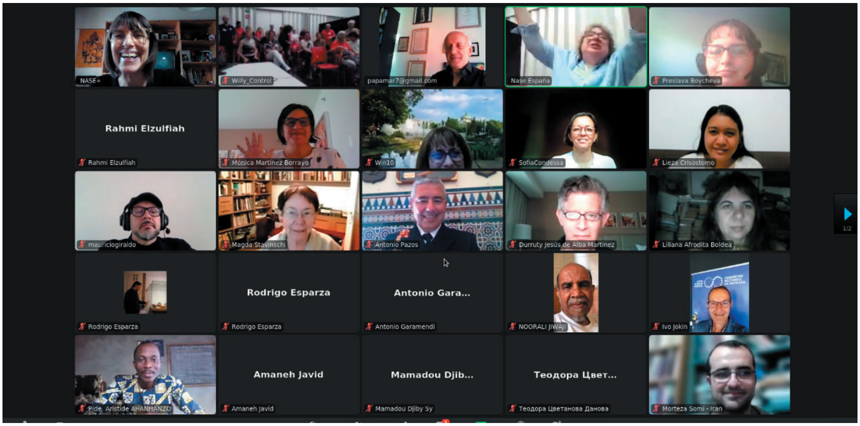


Fig. 61: Some participants in the final event of the project "Latitude to travel and navigate" of UNESCO's International Day of Light 2022, an event organized within the NASE+ cycle (Credit: B. García)

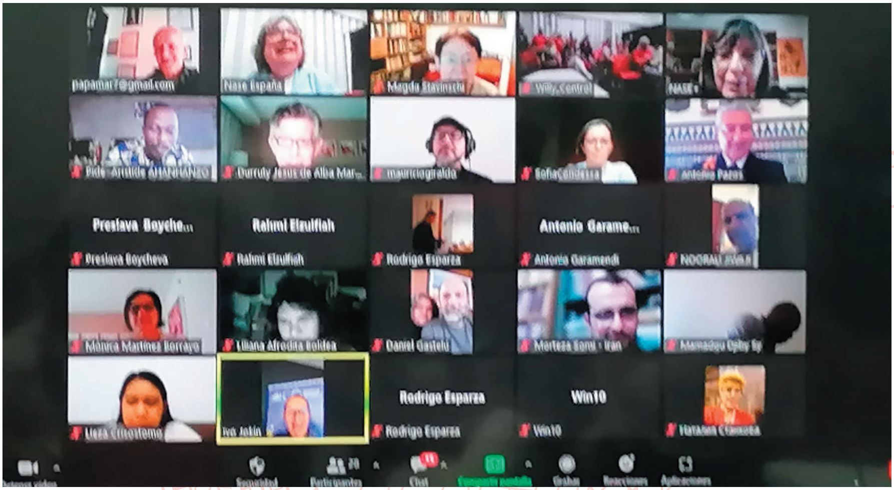
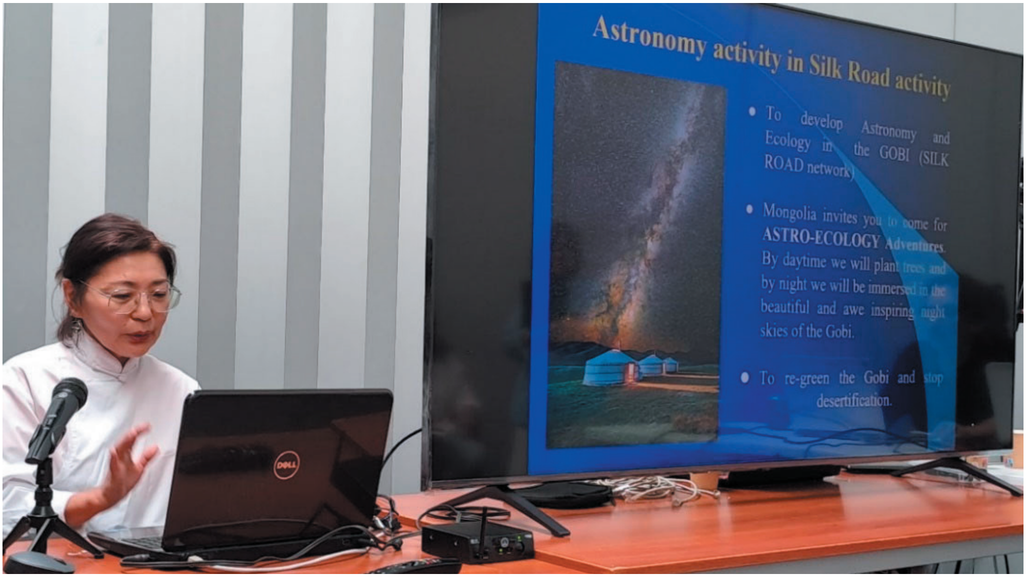


Fig. 62: Other participants in the final event mentioned above (Credit: B. García).

The session was such that a part of its participants were in Spain in person, they were all the teachers who made up the 12 groups who gave the sessions the day before, the rainiest day of October 7 than anyone can imagine. So it was a hybrid event with all the advantages that these events have, easily opening participation and collaboration 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 mayor of Viladecans said goodbye to all the 25 visiting professors (2 France, 2 Italy, 2 Greece, 3 Lithuania, 1 Paraguay, 3 Philippines, 4 Spain, 5 Romania and 3 United States) explaining in detail the interest of the city of Viladecans for citizen science and for the promotion and encouragement of new vocations, totally in line with the objectives of NASE.

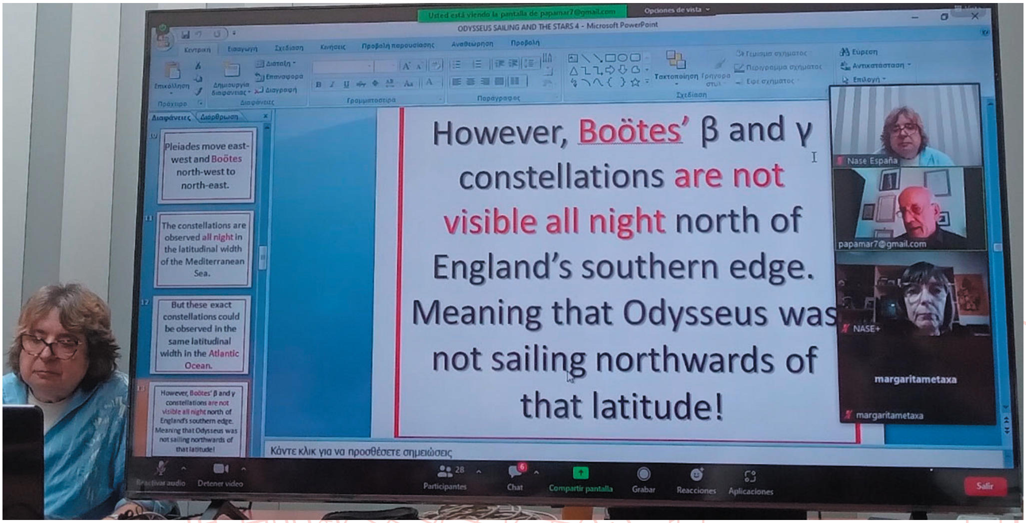
Fig.63: Recognition of the Mayor of Viladecans to the visiting professors invited for the IAU-UNESCO project presented by NASE as a Great Science in Action Experience of Science in Action 2022 (Credit: RM. Ros).



Astronomy activity in Silk Road activity

- To develop Astronomy and Ecology in the GOBI (SILK ROAD network)
- Mongolia invites you to come for ASTRO-ECOLOGY Adventures. By daytime we will plant trees and by night we will be immersed in the beautiful and awe inspiring night skies of the Gobi.
- To re-green the Gobi and stop desertification.

Fig.64: Presentation of Tsolmon Rechin, professor at the University of Mongolia, staff of the Ulaanbaatar Observatory and NASE member, lecturing on the Silk Road (Credit: P. Chis).



Pleiades move east-west and Boötes north-west to north-east.

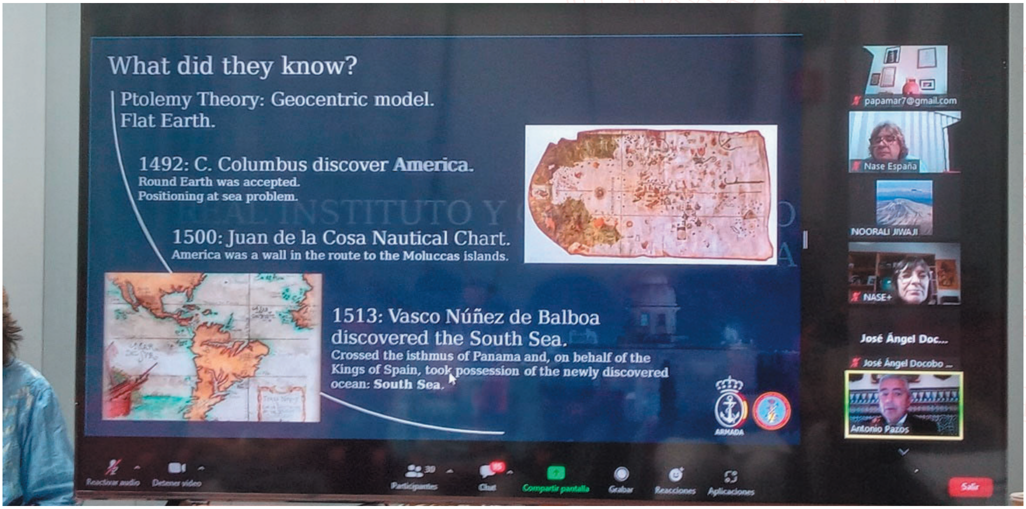
The constellations are observed all night in the latitudinal width of the Mediterranean Sea.

But these exact constellations could be observed in the same latitudinal width in the Atlantic Ocean.

However, Boötes' β and γ constellations are not visible all night north of England's southern edge. Meaning that Odysseus was not sailing northwards of that latitude!

Κάντε κλικ για να προσθέσετε σημειώσεις

Fig. 65: Stavros Papamarinopoulos (Greece) detailing online the astronomical aspects of Homer's Odyssey (Credit: V. Petridou).



What did they know?

Ptolemy Theory: Geocentric model.
Flat Earth.

1492: C. Columbus discover America.
Round Earth was accepted.
Positioning at sea problem.

1500: Juan de la Cosa Nautical Chart.
America was a wall in the route to the Moluccas islands.

1513: Vasco Núñez de Balboa discovered the South Sea.
Crossed the isthmus of Panama and, on behalf of the Kings of Spain, took possession of the newly discovered ocean: South Sea.

Fig. 66: Ship Captain Antonio A. Pazos García, director of the San Fernando Royal Geographic Institute and Observatory of the Navy, gave an online lecture on the voyage of Magellan and Elcano, giving a simple and didactic explanation of the deviation of the dizzy needle (Credit: V. Petridou).

The video of the session can be seen on YouTube, the index of the presentations of the final hybrid session is detailed below:

- ***Opening session***, Beatriz García, Margarita Metaxa and Rosa M. Ros, Argentina, Greece and Spain.
- ***"Mongolia and Silk Road"***, Tsolmon Rechin, National University of Mongolia, Ulaanbaatar, Mongolia
- ***"Chartaquis in the Silk Road"***, Hosein Khezri, ITAU, Bushehr, Iran.
- ***"The use of the stars during Odysseus' sea voyage after the fall of Troy in 1218 B.C."***, Stavros Papamarinopoulos, University of Patras, Greece.
- ***"The ancient relation in Spain between the Milky Way and the St. James Way"***, José Ángel Docobo, Santiago University, Santiago de Compostela, Spain.
- ***Summary of "Determining Latitudes in Viladecans"***, Shila R. Sia, Philippines Normal University, Manila, Philippines and Paula Chis, George Baritiu School, Cluj-Napoca, Romania.
- ***"Elcano. The greatest adventure of history"***, Antonio A. Pazos García, Real Instituto y Observatorio de la Armada, S. Fernando, Cádiz, Spain.
- ***"Treaty of Tordesillas: the Iberian context"***, Sofia Condessa, Associação de Professores de História, Porto, Portugal.

- ***"The meso-american pecked cross as a calendar device: an example of long-distance migration knowledge"***, Rodrigo Esparza López, Centro de Estudios Arqueológicos, Michoacán, Mexico.
- ***"What happened to the north? the Kogi constructions of the Sierra Nevada de Santa Marta"***, Mauricio Giraldo, Museo de Bogotá, Colombia.
- ***Closing session***, Beatriz García, Margarita Metaxa and Rosa M. Ros, Argentina, Greece and Spain.

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 Paula Chis and Shila R. Sia of Colegiul Național George Barițiu, Cluj-Napoca in Romania and the University of Manila in the Philippines respectively.

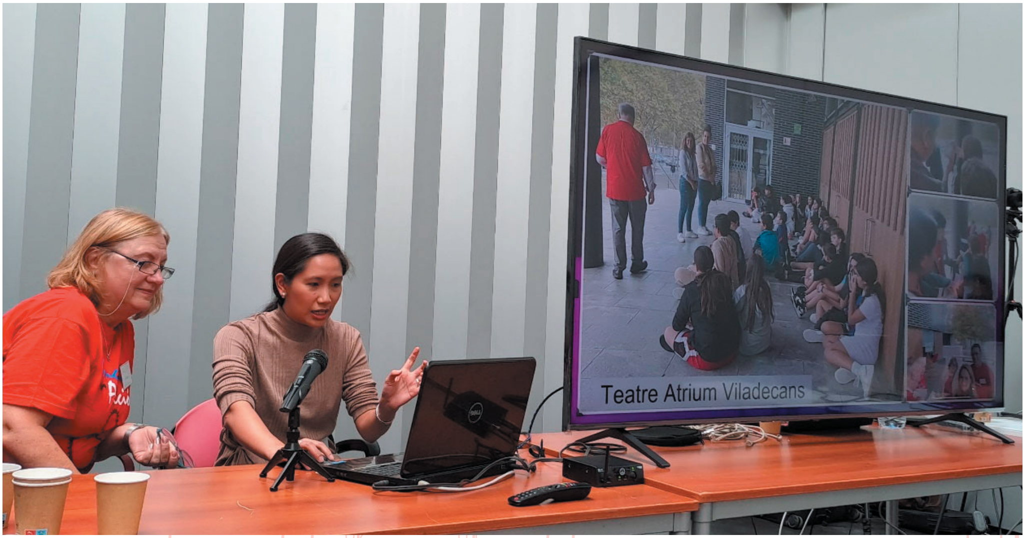


Fig. 67: Summarizing the Great Experience of the previous day so that the online attendees knew the results of it. A very interesting experience that was valued very positively by the students and the teachers of these students, although no type of measurement could be made since it was raining all day (Credit: P. Chis).

Fig. 68: Photograph of the participants meeting in person in Viladecans and who attended the hybrid final together with the online attendees (Credit: RM Ros).

8. Results

NASE received more than a hundred written reports. These works can be seen on the NASE website as mentioned above.

Fig. 69: Distribution by continents of the works received (Credit: L. Torres).

Some reports received include the results obtained using both methods, but the vast majority only used the method of the height of the Sun, since, as is well known, this method can be used in all corners of the globe, while the method of the polar altitude is only possible in the southern hemisphere and for latitudes above about 30°. You can also see photographs of the assembly and conduct of the experiment with the participation of teachers and students. In general, the results are provided by secondary schools, although sometimes there are reports made by universities, observatories, and primary and preschool centres.

The most important thing is not the precision of the results, but understanding the process carried out and how the angle that indicates our latitude and our parallel is deduced.

9. Conclusions

Some reports received include the results obtained using both methods, but the vast majority only use the method of the height of the Sun, since, as is well known, this method can be used in all corners of the globe, while the method of the polar altitude is only possible in the southern hemisphere and for latitudes above about 30º. You can also see photographs of the assembly and conduct of the experiment with the participation of teachers and students. In general, the results are provided by secondary schools, although sometimes there are reports made by universities, observatories, and primary and preschool centres.

The most important thing is not the precision of the results, but understanding the process carried out and how the angle that indicates our latitude and our parallel is deduced:

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 Instituto Etíope de Ciencia y Tecnología Espacial, Ethiopia
Ethiopian Space Science Society, Ethiopia
IFA Instituto para Astrofísica de la Universidad de Viena
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 Instituto Nacional de Investigación Astronómica de Tailandia
Planetario de Beijing, China
Planetario de Oporto, Portugal
Universidad Nacional de Cuyo, Mendoza, Argentina
University of Oporto, Portugal

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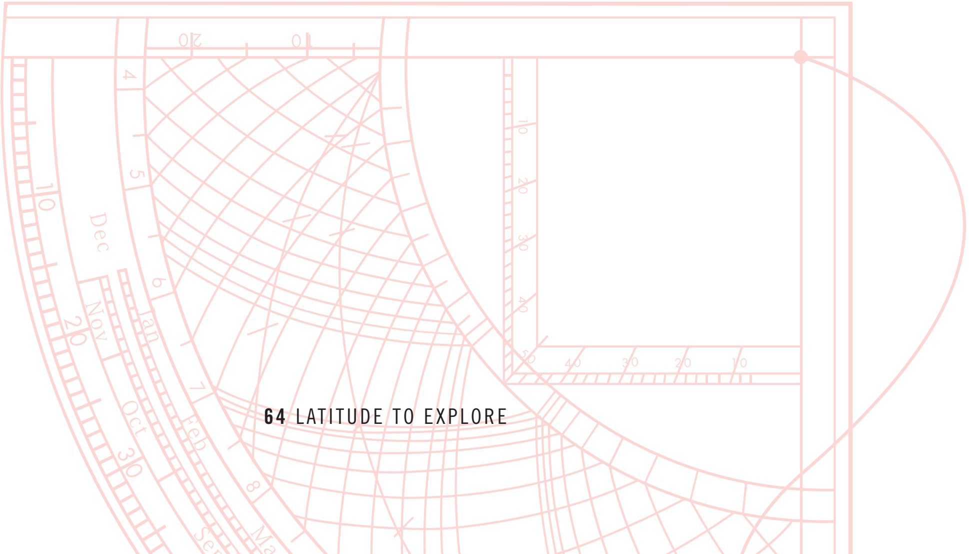

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