Camping under the stars — the ESO Astronomy Camp 2013

On 26 December 2013, after a long and exciting trip, 56 secondary-school students from 18 countries arrived at their destination: the picturesque alpine village of Saint-Barthélemy, Italy, where the Astronomical Observatory of the Autonomous Region of the Aosta Valley (OAVdA) was built because of the area's clear skies.

By Cristina Olivotto, Davide Cenadelli, Oana Sandu, and Lars Lindberg Christensen

On 26 December 2013, a time of year when the nights are long and clear in the Alps, 56 secondary-school students from 18 countries arrived at their destination: the picturesque alpine village of Saint-Barthélemy, Italy, dazzlingly bright under a fresh sprinkle of snow.

The participants quickly got to know each other, shared stories and were soon laughing together. They were all eager to start this unique week at the first ESO Astronomy Camp[w1], hosted by the Astronomical Observatory of the Autonomous Region of the Aosta Valley (OAVdA).

On the first evening, a world map was hung in the lecture room and everyone marked their home country. With all the labels, the map looked very colourful — exactly like the Universe that the curious students were going to learn about.

The camp programme explored the theme of the visible and the invisible Universe through lectures, hands-on activities, and night-time observations with telescopes and instruments at the observatory. Social activities, winter sports, a planetarium show and multicultural tea-time meetings contributed to making the camp a memorable experience for the participants.

Part of their excitement came from the opportunity to spend time with professional astronomers, who

not only shared their knowledge and enthusiasm with the students during the activities but were also so overloaded by questions during meal times that they had little chance to eat the delicious food prepared by the hostel staff!

Looking at the temperature

The programme began with an introduction to visible light and an explanation of how to interpret the light arriving from the stars to calculate their temperatures.

The spectrum of a star is an absorption spectrum: the stellar photosphere – the thin layer where the stellar gas undergoes the transition from opaque to transparent and where light can escape into space – emits light at all wavelengths, but some specific wavelengths are absorbed by the elements at the star's surface. This absorption creates dark lines of missing wavelengths on the spectrum.

In addition, the colour of the star – or, to be more precise, the maximum brightness of the spectrum – depends on the temperature of the stellar photosphere: it shifts towards blue if the star is hotter, and towards red if it is cooler, as explained by the black body laws (see box).

More precisely, the specific wavelengths absorbed by the elements at the surface of the star correspond to the quantity of energy that the electrons in the atoms of those elements need in order to reach a higher level of energy. The energy levels that the electrons occupy change from atom to atom and also depend on the temperature of the gas. Because different stars have similar chemical compositions, the absorbed wavelengths depend mainly on the temperature. So, in a

BACKGROUND

The black body laws state that a hot, dense, and opaque gas emits a continuous spectrum of wavelengths whose maximum brightness moves towards shorter wavelengths when the temperature increases. Because blue light has a shorter wavelength than red light, the colour we see for a star shifts from red for colder stars to orange, yellow, white (when the peak of brightness is in the green, stars actually look white) and finally blue for hotter stars.

Physics

Group photo of the participants of the ESO Astronomy camp

Image courtesy of Paolo Calcidese

first approximation, we can consider that both the colour of a star and the dark lines on its spectrum depend on its temperature. Colour and lines are correlated: blue stars show certain lines and red ones others.

The Harvard Classification

Astronomers understood this crucial correlation in the second half of the 19th century, and established so-called spectral classifications. The most important one, named the Harvard Classification, was created at the beginning of the 20th century and is still in use today with very few changes.

REVIEW

- **Physics**
- **Astronomy**
- **Astrophysics**
- **Spectrometry**
- **Star classifications**
- **Ages 14–18**

As a teacher, one can sometimes come across opportunities available to 16 years old that make one regrets not being 16 years old anymore.

This article promotes the ESO, European Southern Observatory, Astronomy camp, an amazing occasion that some 16 year old students, from any European country, attended in December 2013. This camp balanced exciting astronomical observations and learning from professional astronomers with a healthy sports and social program.

For teachers, this article is an excellent and complete resource to use during an astrophysics lesson for 16 to 18 years old. For younger students, it provides a good introduction to stars classification. The stimulating part of this article is that it offers an easy-to-follow procedure to calculate the surface temperature of stars by analysing their spectra using real data, which is always an added plus to a lesson. It also exposes some of the challenges faced when calculating these temperatures, a possible extension to the work.

Looking at the web references given in this article, I could see that another ESO astronomy camp is planned for this December 2014. Oh, to be 16 again!

Dr Caroline Neuberg, Fulneck School, UK

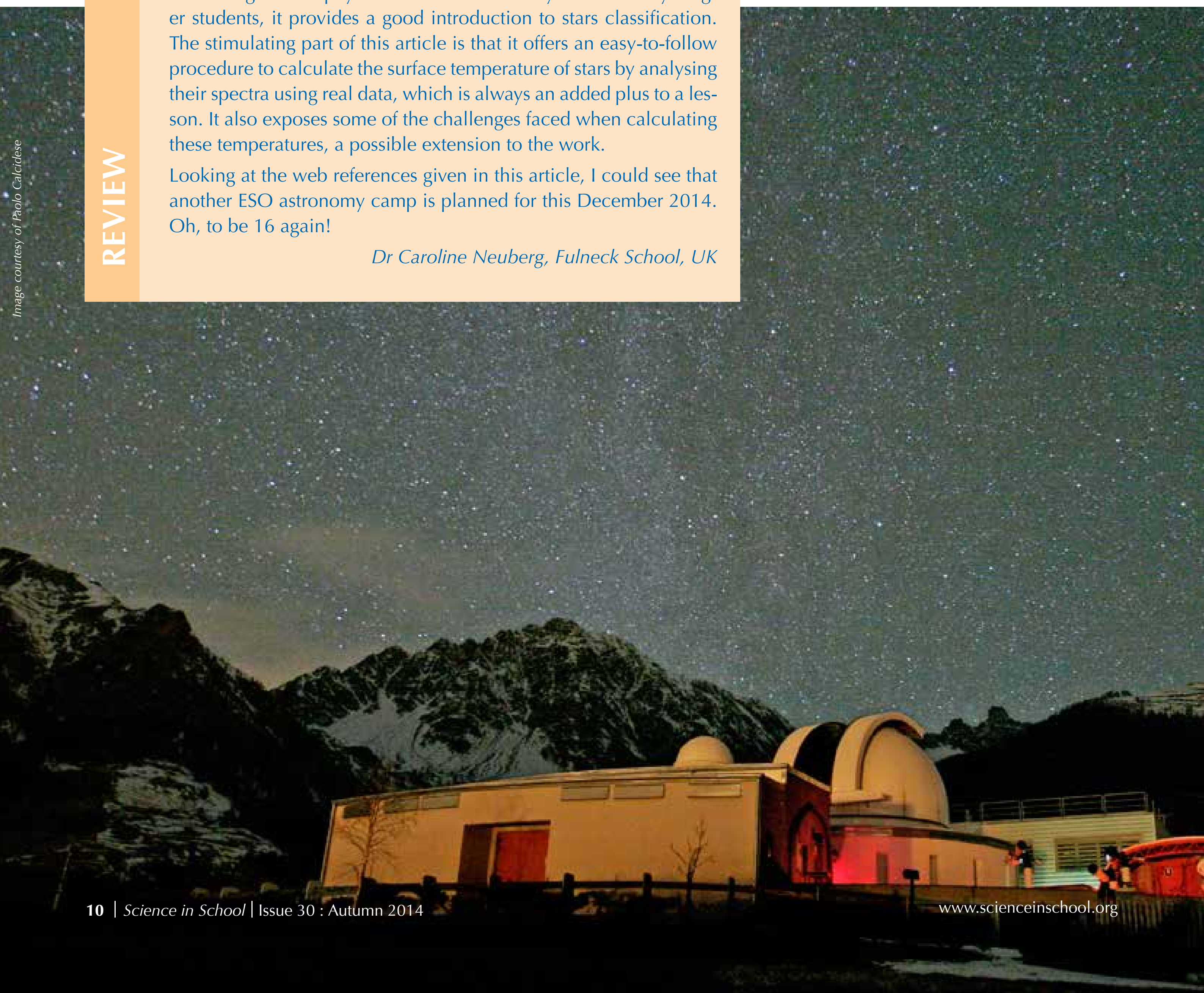

Image courtesy of Paolo Calcidese

The Harvard Classification contains seven major classes: O, B, A, F, G, K and M, in order of decreasing temperature:

- O and B stars are blue;
- A stars are white;
- F and G stars are yellow;
- K stars are orange;
- M stars are red.

Each class is further divided into 10 types, indicated by numbers from 0 to 9, where 0 is the hottest and 9 the coldest. So we have stars that are type A0 (Vega), G2 (Sun) and K5 (Aldebaran), for example.

Image courtesy of Mariona Isern

Participants busy analysing stellar spectra

The observatory of the Aosta Valley

Moreover, stars of the same temperature can have different radii and luminosities. To reflect these variations, a luminosity classification with Roman numerals complements the Harvard Classification:

- Ia are bright supergiants;
- Ib are less bright supergiants;
- II are bright giants;
- III are giants;
- IV are subgiants;
- V are dwarfs.

Physics

The camp was a wonderful experience. Meeting so many people from other cultures with different ways of thinking and the chance to discuss hot topics with them was unique and exciting.

Gabriele, 16, Italy

I am not exaggerating when I say that the night observations were the most exciting part of the camp! We scrutinised stellar spectroscopy together with the observatory staff — one of the most interesting parts of astronomy for me. […] I'm sure what I learned at the ESO Camp will be useful for my future education.

Daniil, 16, Russia

[…] We soon settled into a wonderful routine of astronomy-related lectures and activities interrupted only by meals and winter excursions. […] By the end of the camp I had experienced some of the best days of my life.

Hera, 16, Sweden

Participants solving a mathematical puzzle

Image courtesy of Mariona Isern

Luminosity also has a slight impact on spectrums, but this was not explained in detail at the camp.

The correlation between star colour and spectral lines means that each class in the Harvard Classification is characterised by lines that are typical of the temperature of that class:

- very hot stars show helium lines;
- moderately hot stars show hydrogen lines (the so-called Balmer Series, whose lines are indicated by the symbols Hα, Hβ, Hγ, Hδ …);
- moderately cold stars show lines of neutral and ionised metals;
- very cold stars show lines of neutral metals and molecular bands.

Spectral sequence

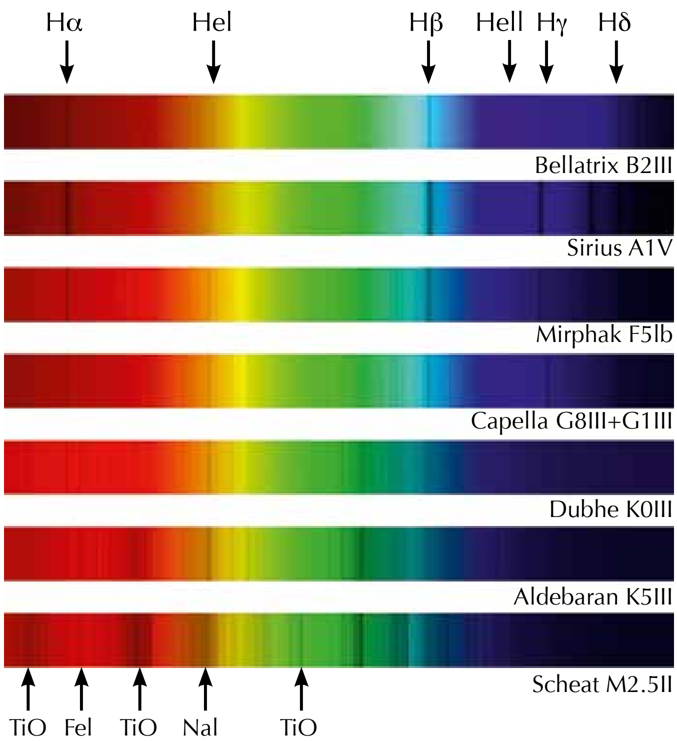

Image courtesy of Davide Cenadelli

Stellar spectra taken by participants of the ESO Astronomy Camp. Below each spectrum, the name, spectral classification and surface temperature of the star are reported. Some major lines and bands are indicated. Note that helium lines are typical of very high temperatures; hydrogen Balmer lines of moderately high ones; neutral sodium lines of low or moderately low temperatures; and molecular bands of the lowest ones.
Colours in this image don't correlate with temperature because they are not corrected for atmospheric extinction and for the charge-coupled device's spectral response.

And much more…

On the first day, students were asked to choose their favourite star from a photo of the winter sky, and to calculate its temperature and maximum emission based on its tabulated spectra.

In the evening, groups of students were able to operate a spectrograph and a charge-coupled device camera attached to one of the didactical telescopes, and to capture the spectra of several favourite stars, among them Aldebaran, Betelgeuse, Dubhe, Mirphak and Sirius.

These newly observed spectra were then used on the following day to calculate the temperatures of the stars and to classify them. The students proved to be excellent team-workers. You can download the step-by-step explanation of how to implement this activity in your classroom, together with the spectra of several stars, from the *Science in School* website[w2].

Lecture after lecture and activity after activity, the astronomers opened new windows on the Universe by letting the students see it in a different light. Curiosity was in the air, and questions were raised and answered about the infrared, radio, ultraviolet and X-ray Universe.

Several other activities based on healthy competition were used to help foster teamwork. The Antares competition, for example, challenged the students to use absorption lines in spectra to classify a number of famous and less famous stars according to the Harvard Classification scheme. The non-oven microwave technology tournament was another activity that engaged six groups in measuring what direction the specific signal received by an antenna came from.

The camp concluded as the International Space Station passed above our heads, an unforgettable traditional gala dinner and astronomical gifts and awards from ESO. Time flew by but the memory of the camp activities and friendships will last forever. We are already looking forward to next year's camp[w3]!

Acknowledgements

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Web references

w1 – To learn more about the first ESO Astronomy Camp, visit its dedicated webpage: www.sterrenlab.com/camps/eso-astronomy-camp-2013/

w2 – You can download the detailed explanation on how to determine the temperature of a star from its spectrum, from the *Science in School* website. See: www.scienceinschool.org/2014/issue30/ESOcamp#w2

w3 – To learn more about the upcoming ESO Astronomy Camp in December 2014, and to register, see: www.sterrenlab.com/camps/eso-astronomy-camp-2014/

Resources

To learn more about the analysis of stars' spectra, read:

Kaler JB (2011) *Stars and their spectra: an introduction to the spectral sequence.* 2nd Ed. Cambridge, UK: Cambridge University Press. ISBN: 9780521899543

Physics

Night sky observation

Image courtesy of Julian Durrwalder

Robinson K (2007) *Spectroscopy: the Key to the Stars.* London, UK: Springer. ISBN: 9780387367866

Our eyes are very limited in their ability to show us the Universe. To learn more about how covering the full spectrum of light can change your perception, read:

Christensen LL, Bob Fosbury B, Hurt R (2009) *Hidden universe.* Berlin, Germany: Wiley-VCH. ISBN: 9783527408665

The European Southern Observatory builds and operates a suite of the world's most advanced ground-based astronomical telescopes. See: www.eso.org

Sterrenlab organises science camps and summer schools around the world and offers services in science education and communication. See: www.sterrenlab.com

The Astronomy Observatory of the Aosta Valley hosts some extremely modern equipment that is used for research, teaching, and promotional purposes. See: www.oavda.it/english/osservatorio/index.htm

The Istituto Nazionale di Astrofisica (National Institute for Astrophysics, INAF) is an important Italian institution for research in astronomy and astrophysics. See: www.inaf.it/en?set_language=en

The University of Milan is one of the most important and largest universities in Europe. See: www.unimi.it/ENG/

Map of Italy showing the Val d'Aosta region

Image courtesy of Gigillo83/Wikimedia commons

The Aosta plain

Image courtesy of Gerrit/Wikimedia commons

The Polish Astronomical Society (Polskie Towarzystwo Astronomiczne, PTA), with headquarters in Warsaw, brings together professional astronomers. See: www.pta.edu.pl

Urania – Postępy Astronomii is a Polish magazine on astronomy for a lay audience. It is one of the oldest astronomy magazines in the world. See: www.urania.edu.pl

Polish Children's Fund is an independent, non-governmental organisation whose main objective is to help gifted pupils. See: http://fundusz.org/english

Ciência Viva is an open programme to promote science in Portugal. See: www.cienciaviva.pt/home/

The Sociedad Española de Astronomía brings together Spanish astronomers and astrophysicists. See: www.sea-astronomia.es/drupal/

The Université de Genève is a public research university and the second-largest university in Switzerland by number of students. See: www.unige.ch/international/index_en.html

If you found this article interesting you may want to browse the other astronomy-related articles on the *Science in School* website, see: www.scienceinschool.org/astronomy

Image courtesy of ESA

The Faulkes Telescope, in Hawaii

Davide Cenadelli graduated in physics and earned his PhD at Milan University. His interests span stellar astrophysics, spectroscopy and the history and philosophy of science. He's currently part of a research group involved in the quest for exoplanets around red dwarfs in the galactic neighbourhood at the Observatory of the Autonomous Region Aosta Valley.

Cristina Olivotto graduated in physics at the University of Milan and received her PhD in the history of physics. After graduation, she began working in the field of science communication and education at the Astronomical Museum of Milan and as a lyceum teacher of physics and mathematics. She worked at the European Space Agency for four years before founding Sterrenlab in 2011.

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Lars Lindberg Christensen is a science communication specialist who is Head of the ESO education and Public Outreach Department (ePOD) in Munich, Germany. He is responsible for public outreach and education for the La Silla-Paranal Observatory, ESO's part of ALMA and APEX, the European Extremely Large Telescope, ESA's part of the Hubble Space Telescope, and the IAU Press Office.

To learn how to use this code, see page 53.

Physics