

MW-GAIA: BRINGING THE MILKY WAY TO SCHOOLS 2021

JUNE
2-4
2021

TOPICS COVERED

- The Milky Way as a Galaxy: the science and research background
- Dissemination of the GAIA science
- Bringing the research closer to the public
- Teaching the Milky Way in schools
- How to make teaching and science communication more inclusive

Deadline for abstract submission: 14 May 2021

Deadline for registrations: 1 June 2021



COST ACTION CA-18104 HOSTED BY
INSTITUTO DE ASTROFÍSICA E CIÊNCIAS DO ESPAÇO (PORTO, PT)
VILNIUS UNIVERSITY (VILNIUS, LT)

Poster 9

ORGANIZERS



Vilnius University

Nadia Kaltcheva¹, Maia Nenkova²

1. University of Wisconsin Oshkosh, USA
2. Seneca College, Toronto, Canada

Interactive Teaching of Astronomy Concepts

Among the STEM disciplines, astronomy is probably the one where the educational aspect benefits most from the field's professional databases and open-source software. Various classroom activities can be developed at both entry and more advanced levels utilizing these extensive resources. We provide examples that could be used to enhance students' understanding of stellar magnitudes and distances, stellar classification, and stellar properties. This approach is helpful in active learning of basic astronomical concepts and techniques, while keeping the emphasis on the latest developments in astronomy.

Interactive Teaching of Astronomy Concepts

Nadia Kaltcheva¹ and Maia Nenkova²

¹Department of Physics and Astronomy, University of Wisconsin Oshkosh, Oshkosh, WI 54901, USA

²School of English and Liberal Studies, Seneca College, Toronto, Canada

1. Summary

Among the STEM disciplines, astronomy is probably the one where the educational aspect benefits most from the field's professional databases and open-source software. Various classroom activities can be developed at both entry and more advanced levels utilizing these extensive resources. We provide examples that could be used to enhance students' understanding of stellar magnitudes and distances, stellar classification, and stellar properties. This approach is helpful in active learning of basic astronomical concepts and techniques, while keeping the emphasis on the latest developments in astronomy.

2. Motivation

General education astronomy courses have always been popular with students. Although students find the subject exciting, they might not develop a good grasp of the objects they study, since they often work with computer simulations and stellar samples provided as lists, or selected from a webpage. One element that is difficult to include, especially in large classes, is observing the night sky and measuring the properties of astronomical objects.

The abundant interactive educational resources in astronomy should be used to overcome this disconnect and let students gain experience in searching for objects and collecting their own data. This will make exploring astronomy-related concepts less abstract, more involving and efficient. In this way even a one-semester introductory astronomy course can provide memorable and lasting experience.

Including observations of the night sky, even in a virtual form, results in a feeling of doing astronomy, instead of following procedures to complete a certain assignment. This approach could be incorporated in the classroom in various ways to cover a wide range of content at a level of difficulty that can vary from simple pre-lab assignments to relatively extended student projects. For example, data can be collected by students using virtual observations with the planetarium software Stellarium, which incorporates rich professional databases of astronomical observations. Stellarium is available for a large number of platforms, including the web-based version Stellarium Web, which is intuitive and easy to use.

We consider several examples related to stellar properties commonly used in introductory astronomy courses. We explore if they could be developed using data available via Stellarium with a purpose to include an element of observations that should enhance students' understanding of stellar magnitudes and distances, spectral classes and classification with H-R diagrams.

3. Brightest and Nearest Stars

The brightest stars are widely used in the classroom to elaborate concepts related to stellar surface temperature, stellar luminosity, stellar radius and the effect of distance on apparent brightness. Samples containing the brightest stars, up to some limiting magnitude, can be easily selected by the students from the web version of Stellarium using the apparent brightness. The sample could be selected to contain the brightest stars of the entire sky (setting the observer's location to North and South poles) or to be specific for the place of the observer (e.g. Chicago in our example, containing the brightest stars seen from Chicago 6 months apart). For the brightest stars Stellarium Web provides the apparent magnitude, the spectral classification and distance from parallax measurements (*Hipparcos* or *Gaia*-based). Combined with appropriate calibrations, the stellar classification yields the spectroscopic absolute magnitude and the spectrophotometric distance (obtained from the distance modulus). Figure 1 illustrates the comparison between the spectroscopic distance and the parallax distance from Stellarium Web for the entire-sky sample and for a location-specific sample, showing a reasonable agreement between the two methods. For these examples we used the calibration by Deutschman, Davis and Schild (1976), as containing data for all spectral types and luminosity classes. The H-R diagrams for both samples, plotted using the spectroscopic magnitudes and coded spectral classes (zero for O-type, 1 for B-type, 2 for A-type, etc.) contain the expected sequences.

Collecting the built-in data for a sample of the nearest stars would require using a list of objects, as most of them are dim red dwarfs not readily seen on the Stellarium screen. Figure 1 (left panels) also includes our sample of nearly 30 nearby stars where the spectroscopic absolute magnitudes and distances are based on the calibration for luminosity class V by Eric Mamajek (Version 2021.03.02; Pecaut, Mamajek, & Bubar, 2012; Pecaut, & Mamajek, 2013). This sample can be used in the context of the stellar content of the immediate solar vicinity. Since half of these stars are members of double and multiple systems, the use of this sample can be further expanded.

This Stellarium-based approach can be easily implemented in introductory astronomy courses to illustrate the sequence of obtaining astrophysical information related to stellar parameters. The approach is feasible, and provides an opportunity for students to familiarize themselves with the objects they study.

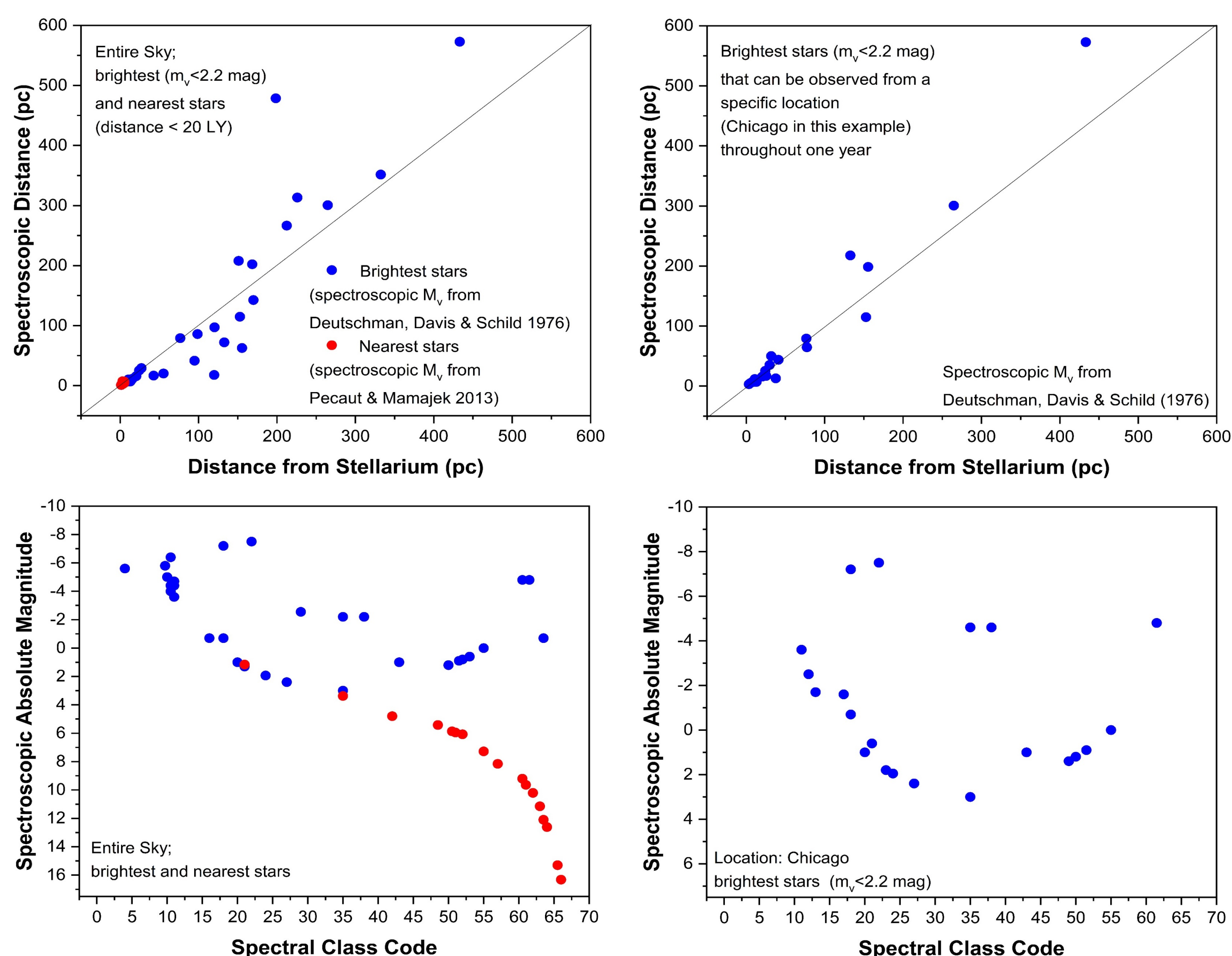


Figure 1 Top: Comparisons between spectroscopic and parallax distances for the brightest stars (blue) and for the nearest stars (red). Bottom: the corresponding H-R diagrams. The spectral class codes correspond to the spectral types obtained from Stellarium. Absolute magnitudes are determined from the calibrations indicated on the panels.

References

Deutschman, W. A., Davis, R. J., Schild, R. E., 1976, *ApJS*, 30, 97
Kaltcheva, N., & Pritzl, B., 2018, "Using stellar spectra to illustrate thermal radiation laws", *Phys. Educ.* 53 035022
Kardaras, I., & Kallery, M., 2020, *Physics Education*, Volume 55, Issue 4, id.045010
Pecaut, M.J., Mamajek, E.E., & Bubar, E. J., 2012, *ApJ* 756, 154
Pecaut M.J., & Mamajek, E. E., 2013, *ApJS*, 208, 9, available on http://www.pas.rochester.edu/~emamajek/EEM_dwarf_UBVIJK_colors_Teff.txt

4. Open Clusters

Star clusters are used in the astronomy classroom to reinforce concepts about stellar properties and to illustrate stellar evolution. Stellarium Web provides options for students to explore both open and globular clusters. The Pleiades (M45), as a nearby almost reddening-free open cluster, is often used as an example. The data that can be collected from Stellarium for the individual stars in the cluster's field (apparent magnitude, spectral type and parallax distance) yield an easy determination of the cluster's distance, based on both spectroscopic and parallax methods (Fig. 2). Since the interstellar reddening for the Pleiades is small, it could be neglected for the purpose of this exercise. Students can compare the results of the two methods, talk about stars that belong to the cluster, the foreground and background stars, the importance of the Pleiades for the cosmic distance scale, etc.

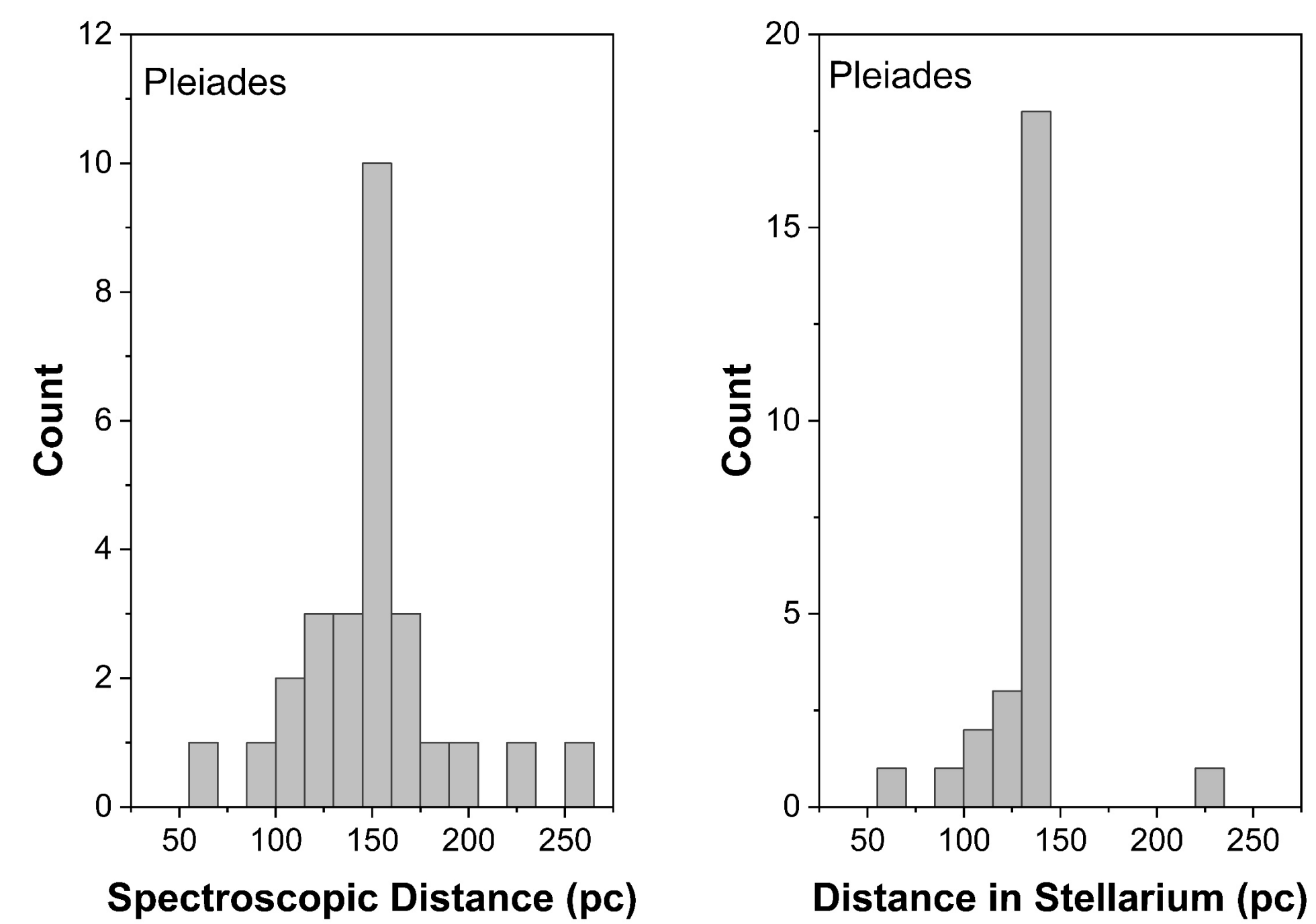


Figure 2 Histograms of the spectroscopic distances (left) and parallax distances (right) for a sample of stars in the field of the Pleiades. The sample contains 27 stars that are randomly selected with the only constraint to be main sequence stars (in order to use the calibration maintained by E. Mamajek that is readily accessible online). The sample can be extended to include all luminosity classes. Such randomly selected samples reproduce well the accepted distance to the cluster and can be incorporated in various classroom activities.

Considering distant clusters would require reddening corrections and could not always provide numerical values easy to use in the classroom because of the limitations of the spectroscopic parallax method. Figure 3 illustrates a possible activity using the double cluster in Perseus (NGC 869 and NGC 884). After an average reddening correction is applied for each cluster (e.g. taken from the WEBDA database), the histograms of the spectroscopic distances accurately reflect the offset in distance between the clusters. Although the histograms are affected by the limited selection and inclusions of foreground stars, in addition to inaccuracies in the spectroscopic absolute magnitudes, they are still valuable to illustrate distance determination for open clusters in the Milky Way.

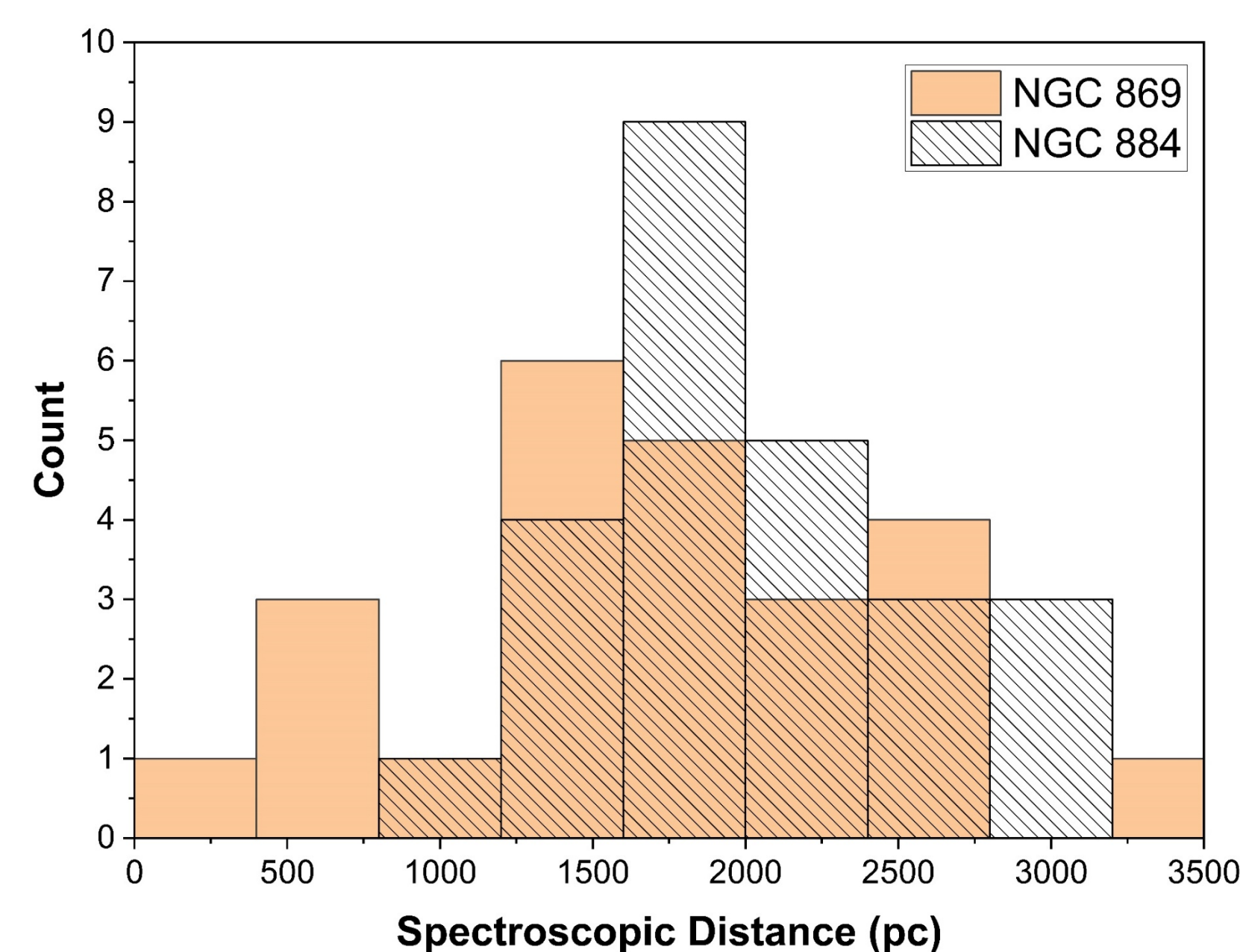
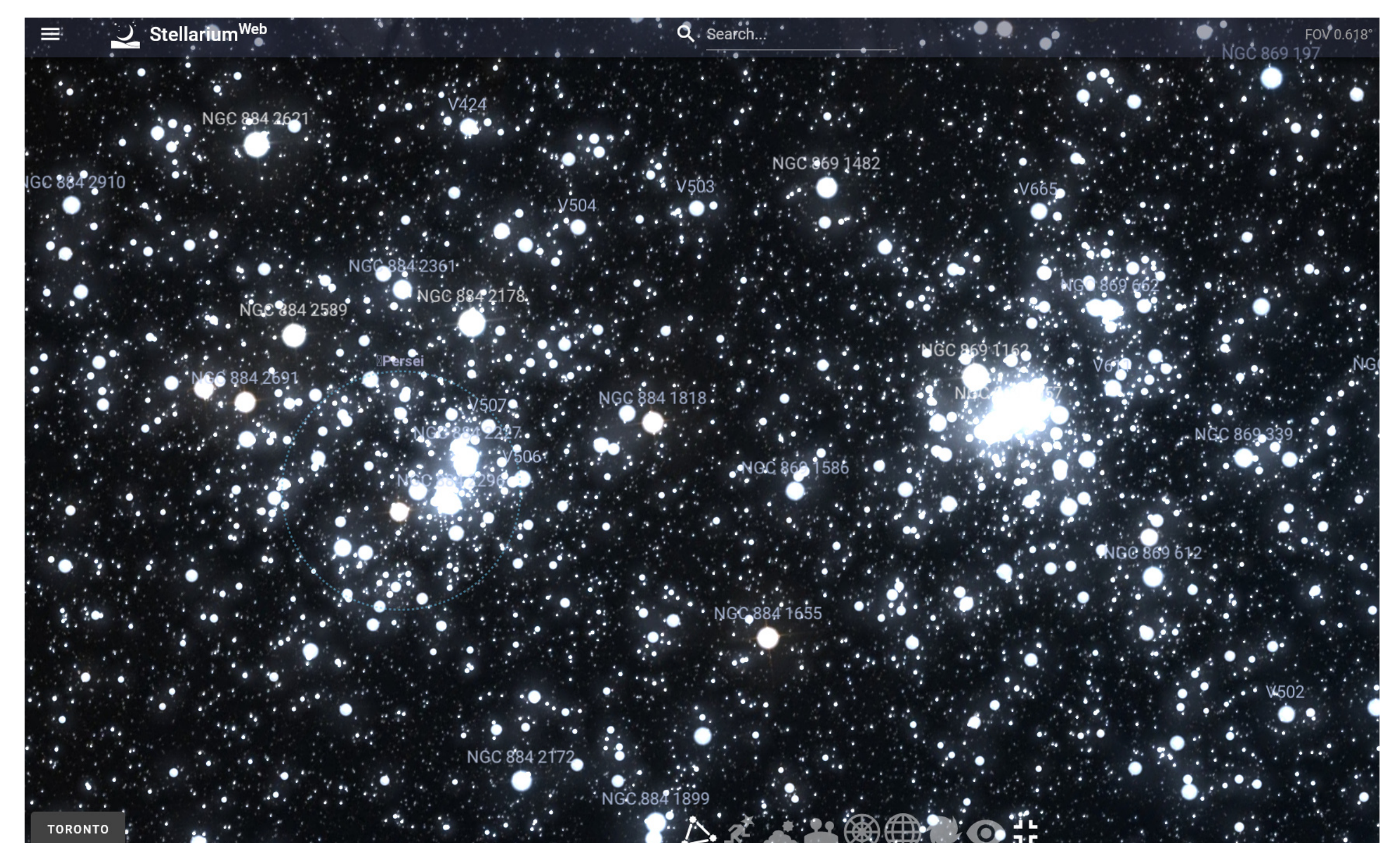


Figure 3 The double cluster in Perseus (NGC 869 and NGC 884): screenshot from Stellarium Web and comparison of the histograms of the spectroscopic distances for samples of main sequence stars.

5. Further Examples of Implementing Stellarium Web

In addition to these relatively extended activities, Stellarium Web can be used for a number of simpler tasks. For example, the stellar magnitude scale can be introduced in an interactive way. It is very helpful for students to see the relation between apparent brightness of a star on the Stellarium Web screen and the numerical value of its visual magnitude. With the parallax distances for the brightest stars, included in the planetarium software, students can explore constellations to discover that the stars within a constellation are not physically related, and can be at very different distances from us. The relation between apparent magnitude, absolute magnitude and distance can also be introduced in an interactive way.

Since an impression of the stellar color is visible in the planetarium software for the brightest stars, this can be used to make the connection stellar color – spectral type – effective surface temperature. Combined with stellar spectra this can be elaborated further to illustrate the Stefan-Boltzmann and Wien's laws. More details on the application of stellar spectra to the physics/astronomy classroom can be found in Kaltcheva & Pritzl (2018) and Kardaras & Kallery (2020).

Acknowledgements

This research has made use of Stellarium Web – the online planetarium run in a web browser, originally created by Fabien and Guillaume Chereau, available on <https://stellarium-web.org>. This research has made use of the Stellarium planetarium (Zotti, G., Hoffmann, S. M., Wolf, A., Chereau, F., & Chereau, G. (2021). The Simulated Sky: Stellarium for Cultural Astronomy Research. *Journal of Skyscape Archaeology*, 6(2), 221–258. <https://doi.org/10.1558/jsa.17822>). This research has made use of the NASA's Astrophysics Data System (<http://www.adsabs.harvard.edu>), the SIMBAD database, operated at CDS, Strasbourg, France (<http://cdsweb.u-strasbg.fr>), and the European Space Agency (ESA) mission Gaia (<http://www.cosmos.esa.int/gaia>), processed by the Gaia Data Processing and Analysis Consortium (DPAC, <http://www.cosmos.esa.int/web/gaia/dpac/consortium>). Funding for the DPAC has been provided by national institutions, in particular the institution participating in the Gaia Multilateral Agreement. This study has made use of the WEBDA open cluster database operated at the Department of Theoretical Physics and Astrophysics of the Masaryk University.