The Sky is for Everyone — Outreach and Education with the Virtual Observatory

Resources

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Summary

The Virtual Observatory (VO) is an international project to collect astronomical data (images, spectra, simulations, mission-logs, etc.), organise them and develop tools that let astronomers access this huge amount of information. The VO not only simplifies the work of professional astronomers, it is also a valuable tool for education and public outreach (EPO). For teachers and astronomers who actively promote astronomy to the public the VO is a great opportunity to access and use real astronomical data, and have a taste of the daily life of astronomers.

Introduction

Astronomy is a very attractive science for teachers, students and the public, allowing them to carry out experiments and observations with relatively simple and inexpensive tools. Of course, having access to a telescope dramatically increases interest in astronomy, both for the public and for schools. However, even if the internet has made many resources available online, public access to remotely controlled telescopes (e.g, the Faulkes telescope and others) remains limited. This is mainly because time slots are in short supply and, moreover, are not easily scheduled during classroom hours.

In this paper we present the Virtual Observatory for Schools and Public (the result of Work Package 5 of the Astronomical Infrastructure for Data Access project — AIDA-WP5). AIDA-WP5 is a free resource developed within the (European) Virtual Observatory project. The aim of AIDA-WP5 is to give access to VO data using professional-level software tools that have been specially modified to make them appealing and easily usable. This gives students, teachers and members of the public access to tools which share the look and feel of those used by professional astronomers.

AIDA-WP5 is not simply a door to VO resources: it is a self-contained resource offering a set of activities that includes interesting astronomical problems to be solved using free software tools and data. Activities are presented in documents that both set out the astronomical problem and give instructions for how to solve it using VO tools and data. AIDA-WP5 complements, or even substitutes for, access to real telescopes with the obvious advantage of being flexible.

In the following we briefly describe the Virtual Observatory and, in particular the EuroVO-AIDA project; we then describe in detail the tools and activities that we have developed for the EPO work package of the AIDA project. Finally, in the last section we give a short account of our direct experiences of using AIDA-WP5 tools in schools.

The formation of the Virtual Observatory

In ancient times, astronomers looked at the sky with their naked eyes and noted their observations on clay tablets, parchment, papyrus and paper. When Galileo Galilei introduced the telescope to astronomy, this process did not change: astronomical observations and scientific results were published and stored in books and papers. When photographic plates came into common use, observatories had to

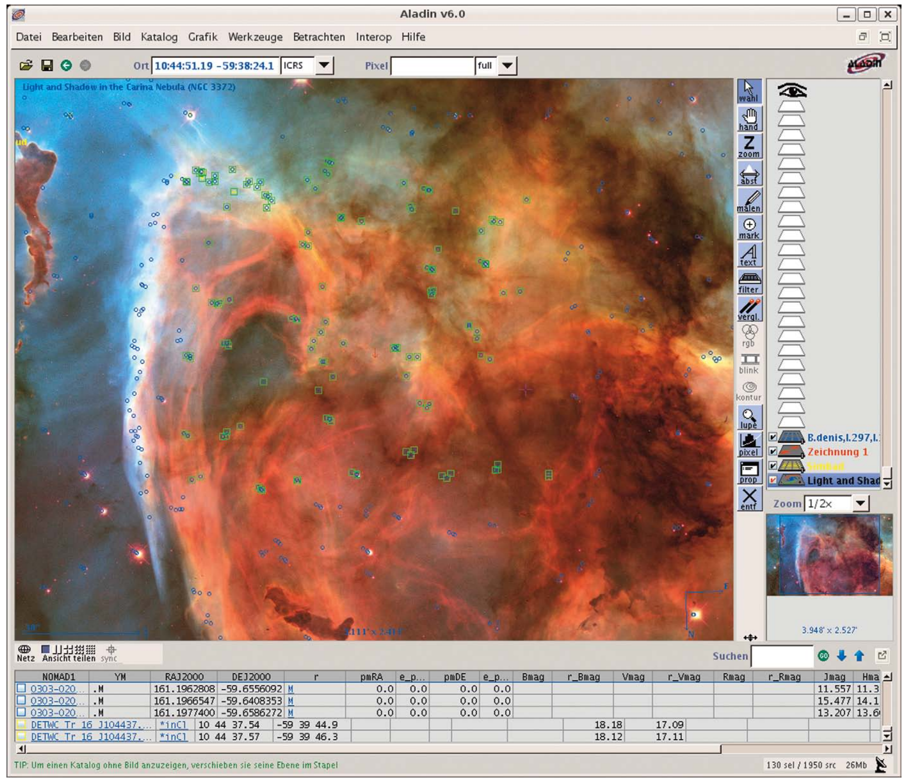


Figure 1. The VO-software Aladin; depicting an image of the Carina Nebula taken by the Hubble Space Telescope with an overlay of catalogue data from the Vizier Database. Credit: Authors, NASA, ESA, CDS.

store them too because they constituted the raw data and formed a valuable scientific archive. Nowadays we image the sky directly to a file on a computer and store our data digitally. Observatories all over the world, together with astronomical satellites, probes and telescopes in space, produce vast amounts of digital data every day and night.
In the past, accessing the collection of photographic plates of a certain observatory was difficult. Inspecting the plates either involved travelling to the observatory itself, or requesting plates to be shipped — which took a long time and ran the risk of damaging or destroying them. Today, however, exchanging digital data is very easy and can be done via the internet rapidly and without complications.

Thus, thanks to the internet, every astronomer can, in principle, easily access and profit from the observations made by all other astronomers worldwide. In practice however, a complex infrastructure is needed to collect and distribute the multitude of astronomical data. Since data are stored in different formats and according to different standards, internet communications and exchanges have to obey protocols of communication and pass several processes of verification. This infrastructure is provided by the Virtual Observatory (VO).

The International Virtual Observatory Alliance (IVOA) was established in 2002. The IVOA now comprises 17 VO projects from Armenia, Australia, Brazil, Canada, China, Europe, France, Germany, Hungary, India, Italy, Japan, Korea, Russia, Spain, the United Kingdom and the United States. Its mission is to:

"facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory."[1]

In order to explain some of the reasons for setting up a VO, consider the following: often, images taken by one observer are also of great value for another astronomer who is researching a totally different topic in the same part of the sky. Typically, the two astronomers would not be aware of one another and the second scientist would perform his own observations — producing a duplicate of the same data already archived by the first. But thanks to the VO, the observations made by the first astronomer can be easily found and used by the second, bringing a significant increase in efficiency and reduction of costs.

Ultimately, the goal of the VO project is to provide a skin beneath which the complexities of varied data coming from different instruments, telescopes and data centres can be concealed: as seen by an astronomer, the VO should look like a normal telescope.

Scientists are not the only group that can profit from the Virtual Observatory. Amateur astronomers can access professional data through the VO and use it for their work. And they are also able to submit their own observations, thus contributing directly to scientific research.

In addition, the VO is a great opportunity for teachers, students and in general for the public. Most data in the VO is available to everybody, whether or not they are astronomers — and in principle everyone should be able to access the same scientific data and tools as professional astronomers. However, without proper explanations, professional data and specialised tools are of little use for laypersons and non-professional astronomers.

Euro-VO AIDA for education and public outreach

In the framework of the European Euro-VO AIDA project[2], which is funded by the European Commission under the Research

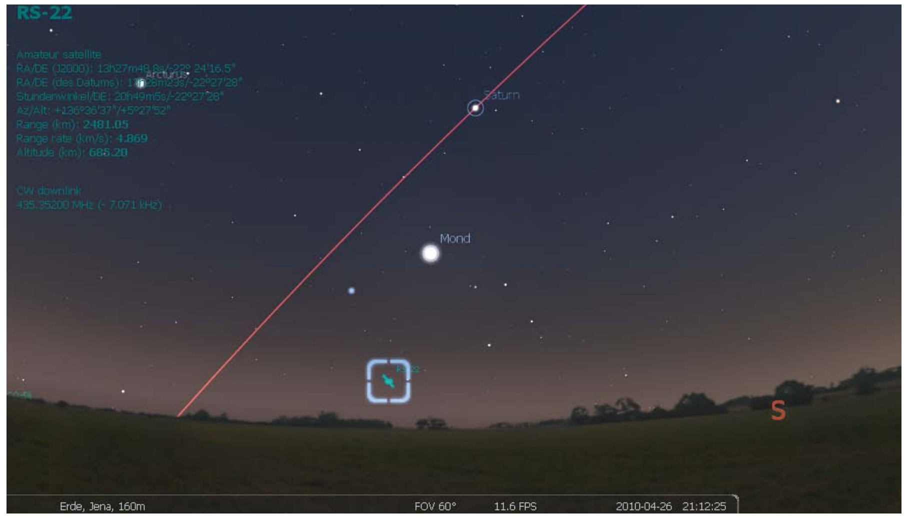
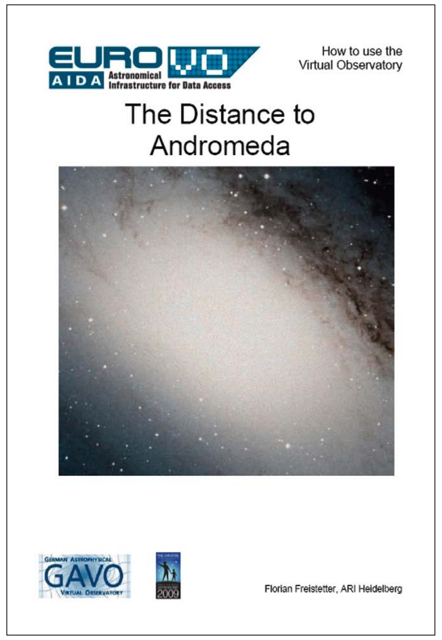


Figure 2. Stellarium shows how the sky looks. The Moon, a satellite and the orbit of Saturn are visible. Credit: ESO & the authors


EURO-VO AIDA Astronomical Infrastructure for Data Access

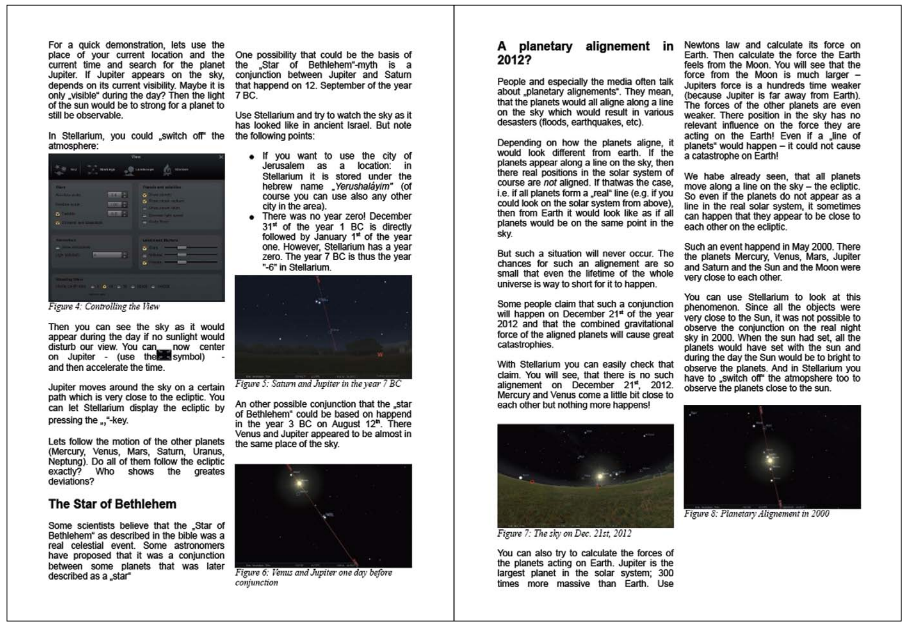
How to use the Virtual Observatory

The Distance to Andromeda

GAVO German Astrophysical Virtual Observatory

Florian Freistetter, ARI Heidelberg

Figure 3. Example of an activity: measuring the distance to the Andromeda Galaxy with Aladin. Credit: Authors


For a quick demonstration, lets use the place of your current location and the current time and search for the planet Jupiter. If Jupiter appears on the sky, depends on its current visibility. Maybe it is only „visible" during the day? Then the light of the sun would be to strong for a planet to still be observable.

In Stellarium, you could „switch off" the atmosphere:

Figure 4: Controlling the View

Then you can see the sky as it would appear during the day if no sunlight would disturb our view. You can now center on Jupiter - (use the symbol) - and then accelerate the time.

Jupiter moves around the sky on a certain path which is very close to the ecliptic. You can let Stellarium display the ecliptic by pressing the „,"-key.

Lets follow the motion of the other planets (Mercury, Venus, Mars, Saturn, Uranus, Neptung). Do all of them follow the ecliptic exactly? Who shows the greates deviations?

The Star of Bethlehem

Some scientists believe that the „Star of Bethlehem" as described in the bible was a real celestial event. Some astronomers have proposed that it was a conjunction between some planets that was later described as a „star"

One possibility that could be the basis of the „Star of Bethlehem"-myth is a conjunction between Jupiter and Saturn that happend on 12. September of the year 7 BC.

Use Stellarium and try to watch the sky as it has looked like in ancient Israel. But note the following points:

- If you want to use the city of Jerusalem as a location: in Stellarium it is stored under the hebrew name „*Yerushaláyim*" (of course you can use also any other city in the area).
- There was no year zero! December 31st of the year 1 BC is directly followed by January 1st of the year one. However, Stellarium has a year zero. The year 7 BC is thus the year "-6" in Stellarium.

Figure 5: Saturn and Jupiter in the year 7 BC

An other possible conjunction that the „star of Bethlehem" could be based on happend in the year 3 BC on August 12th. There Venus and Jupiter appeared to be almost in the same place of the sky.

Figure 6: Venus and Jupiter one day before conjunction

A planetary alignement in 2012?

People and especially the media often talk about „planetary alignements". They mean, that the planets would all aligne along a line on the sky which would result in various desasters (floods, earthquakes, etc).

Depending on how the planets aligne, it would look different from earth. If the planets appear along a line on the sky, then there real positions in the solar system of course are *not* aligned. If thatwas the case, i.e. if all planets form a „real" line (e.g. if you could look on the solar system from above), then from Earth it would look like as if all planets would be on the same point in the sky.

But such a situation will never occur. The chances for such an alignement are so small that even the lifetime of the whole universe is way to short for it to happen.

Some people claim that such a conjunction will happen on December 21st of the year 2012 and that the combined gravitational force of the aligned planets will cause great catastrophies.

With Stellarium you can easily check that claim. You will see, that there is no such alignement on December 21st, 2012. Mercury and Venus come a little bit close to each other but nothing more happens!

Figure 7: The sky on Dec. 21st, 2012

You can also try to calculate the forces of the planets acting on Earth. Jupiter is the largest planet in the solar system; 300 times more massive than Earth. Use Newtons law and calculate its force on Earth. Then calculate the force the Earth feels from the Moon. You will see that the force from the Moon is much larger – Jupiters force is a hundreds time weaker (because Jupiter is far away from Earth). The forces of the other planets are even weaker. There position in the sky has no relevant influence on the force they are acting on the Earth! Even if a „line of planets" would happen – it could not cause a catastrophe on Earth!

We habe already seen, that all planets move along a line on the sky – the ecliptic. So even if the planets do not appear as a line in the real solar system, it sometimes can happen that they appear to be close to each other on the ecliptic.

Such an event happend in May 2000. There the planets Mercury, Venus, Mars, Jupiter and Saturn and the Sun and the Moon were very close to each other.

You can use Stellarium to look at this phenomenon. Since all the objects were very close to the Sun, it was not possible to observe the conjunction on the real night sky in 2000. When the sun had set, all the planets would have set with the sun and during the day the Sun would be to bright to observe the planets. And in Stellarium you have to „switch off" the atmopshere too to observe the planets close to the sun.

Figure 8: Planetary Alignement in 2000

Figure 4. Example of an activity: learning about planetary conjunctions in Stellarium. Credit: Authors.

Infrastructure FP7, a special effort is being made towards education and public outreach. The fifth of AIDA's eight work packages is dedicated to developing tools and methods to let students, teachers and the public in general benefit from the European investment in the VO.

As a first step, we chose existing professional software tools for the retrieval, visualisation and analysis of VO data in order to adapt them for educational and outreach purposes. One of the most popular tools to access the VO is the Aladin program, developed by the Centre de Données Astronomiques de Strasbourg (CDS). In its professional version, Aladin is too complicated and contains too many specialised functions to be of any interest for non-professional users. We therefore created a simpler, more accessible version of Aladin.

A second valuable tool used and modified by AIDA is the sky browser Stellarium, developed by the European Southern Observatory (ESO). It simulates the night sky, including the motion of stars and planets, at any given location around the world and for any given date.

Using and adapting Aladin and Stellarium, it was our goal to develop tools that enable everyone — and not only professional astronomers — to (virtually) observe the sky and access all relevant data. For this purpose, it was not only necessary to provide the software; there was also a need for examples and use-cases that demonstrate how to use Aladin and Stellarium in an easy and comprehensible way. As a result, besides the development of the software, it was also our task to collect and create examples that show how the data in the VO can be accessed and used.

We chose the use-cases in order to apply them in schools, universities and public outreach. The VO is a great opportunity for teachers to introduce students to real astronomical data and the methods to work with it. We have developed a series of such activities of different complexities that are adequate for students of different ages and deal with different astronomical topics ranging from the distribution of asteroids to the distance of the galaxies.

A typical use-case that can be employed in a school or a beginners' astronomy lecture at a university deals with a concrete topic, like the determination of the distance of the Andromeda Galaxy. Every activity starts with a general introduction.

For example, in the case of the Andromeda Galaxy, it gives a short background briefing on the history and importance of distance measurements in astronomy. Less than 100 years ago, we did not even know if our Milky Way was all there was in the Universe or if the faint nebulae observed in the sky might be distant islands of stars similar to our own galaxy. To resolve that dispute, astronomers had to measure the correct distances to these nebulae. This was done by Edwin Hubble in 1924 by using the relation between the brightness and the period of variable stars known as Cepheids. The discovery by Edwin Hubble that the Andromeda Nebula was in fact an extremely distant galaxy full of stars and that our Universe consisted of myriads of such galaxies, which apparently move away from us ever faster the further they are away, was revolutionary and changed astronomy and the way we view the world.

Making use of the tools and data from the VO, it is easy for students to retrace Edwin Hubble's steps using real astronomical data.

In our activity we show that with Aladin, one can not only access many astronomical images, but also a vast number of stellar measurements and catalogues. It is easy to retrieve observational data of all the Cepheid stars in the Andromeda Galaxy and use Aladin's built-in spreadsheet tools to process these measurements in the same way as Edwin Hubble did when he was calculating the distance to Andromeda.

Other Aladin educational activities developed by the AIDA-team include scenarios on the motion of stars, the confirmation of supernovae or the properties of stars in the Pleiades[3]. For younger students or the general public who are not willing or able to carry out astronomical calculations, we have developed other activities that make use of the Stellarium sky browser.

One such example deals with the widespread myth of a world-ending catastrophe on 12 December 2012; popularised all over the world as the main theme of Roland Emmerich's blockbuster movie *2012*. A major claim of the 2012-doomsayers is that exactly on 21 December 2012 the planets of the Solar System will align perfectly to form a straight line and the resulting gravitational perturbations will disrupt the Earth or at least cause major catastrophes (floods, earthquakes, etc). This claim can easily be refuted by using a desktop planetarium, like the VO-compatible Stellarium.

In our activity we again start with a general introduction that explains how the planets in the Solar System move and how this

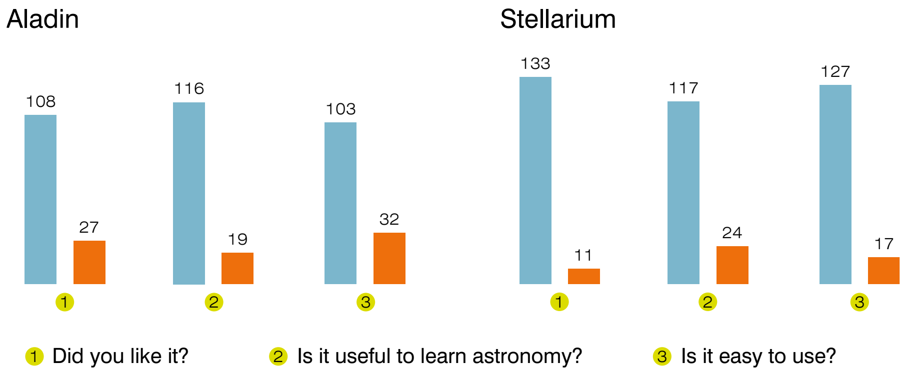


Figure 5. Evaluation of Aladin and Stellarium. Blue bars give the number of students who answered "Yes"; orange is the number of people who answered "No". Credit: Authors.

results in the astronomical phenomenon of conjunctions. We then show how one can depict the position of the planets for any given time and place and give examples of interesting conjunctions in the past (e.g., the conjunction of May 2000 or the conjunction of Jupiter and Saturn in the year 7 BCE that may be the basis for the story of the Star of Bethlehem). We also show that it is easy to confirm that there will be no special alignment in the year 2012 and give instructions on how to calculate the (negligible) gravitational effect on Earth if there ever were to be such a conjunction.

Classroom experiences with AIDA-WP5

Led by the Astronomical Observatory of Trieste (OATS), the AIDA/WP5 activities were applied and tested in many Italian schools with students aged 14 and 18. Four hours of teaching were dedicated to each activity: one hour each to introduce the astronomical background and the concept of the VO and two hours were reserved for the students to actually work on the problems.

More than more than 1500 students and 200 teachers know and have used AIDA-WP5 and helped us improve our tools and use-cases. Figure 5 shows some results of the evaluation.

Additional input came from various groups of amateur astronomers. Currently, a campaign is running to see if teachers can work with the activities without help and supervision by professional astronomers.

Conclusions

Astronomy is a science that fascinates not only professional astronomers, but also the general public. The AIDA-WP5 project is an attempt to make the large collection of astronomical data that is freely available both accessible and understandable for everyone who is interested in the sky. The goal is to obtain a set of dedicated tools and examples that can be used by teachers at schools and universities, by amateur astronomers and people working in public outreach in order to understand the concept of the VO and deploy it autonomously.

Figure 6. Massimo Ramella (OATS) introducing the Virtual Observatory to students at an Italian school. Credit: Authors.

The Virtual Observatory should become a standard tool not only for professional astronomers, simplifying their work, but also for anyone who wants to introduce people to the vast amount of knowledge and beauty that is uncovered by astronomical research.

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Notes

[1] For details see http://ivoa.net/

[2] For details on EURO-VO AIDA see http://www.euro-vo.org/

[3] All use-cases and software can be downloaded from: http://wwwas.oats.inaf.it/aidawp5/eng_download.html?fsize=medium

Biographies

Florian Freistetter is an astronomer, working for the European Virtual Observatory EURO-VO at the Astronomisches Recheninstitut of the University Heidelberg (Germany). Previously he has investigated the dynamics of asteroids and extrasolar planets at the observatories of the universities of Vienna and Jena. He is the author of the ScienceBlog Astrodicticum Simplex (http://www.scienceblogs.de/astrodicticum-simplex/)

Giulia Iafrate works on astronomy outreach and education at the Astronomical Observatory of Trieste (Italy). She also collaborates with the Italian National Institute for Nuclear Physics in the analysis of the data of the Fermi-LAT satellite.

Massimo Ramella is associate astronomer at the INAF-Osservatorio Astronomico di Trieste. He coordinates the outreach and education activities of OATS. He is the team leader of Work Package 5 of the Euro-VO AIDA project. His field of research includes the large-scale structure of the Universe and systems of galaxies.