The Virtual Observatory for Education

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VO 4 Edu and Euro-VO

The goal, since 2008:

- Spark the interest on and share the excitement of research in astronomy
- Let students experience the astronomer's work in the classroom

Target:

- Mainly 13 yr to 18 yr old students + university

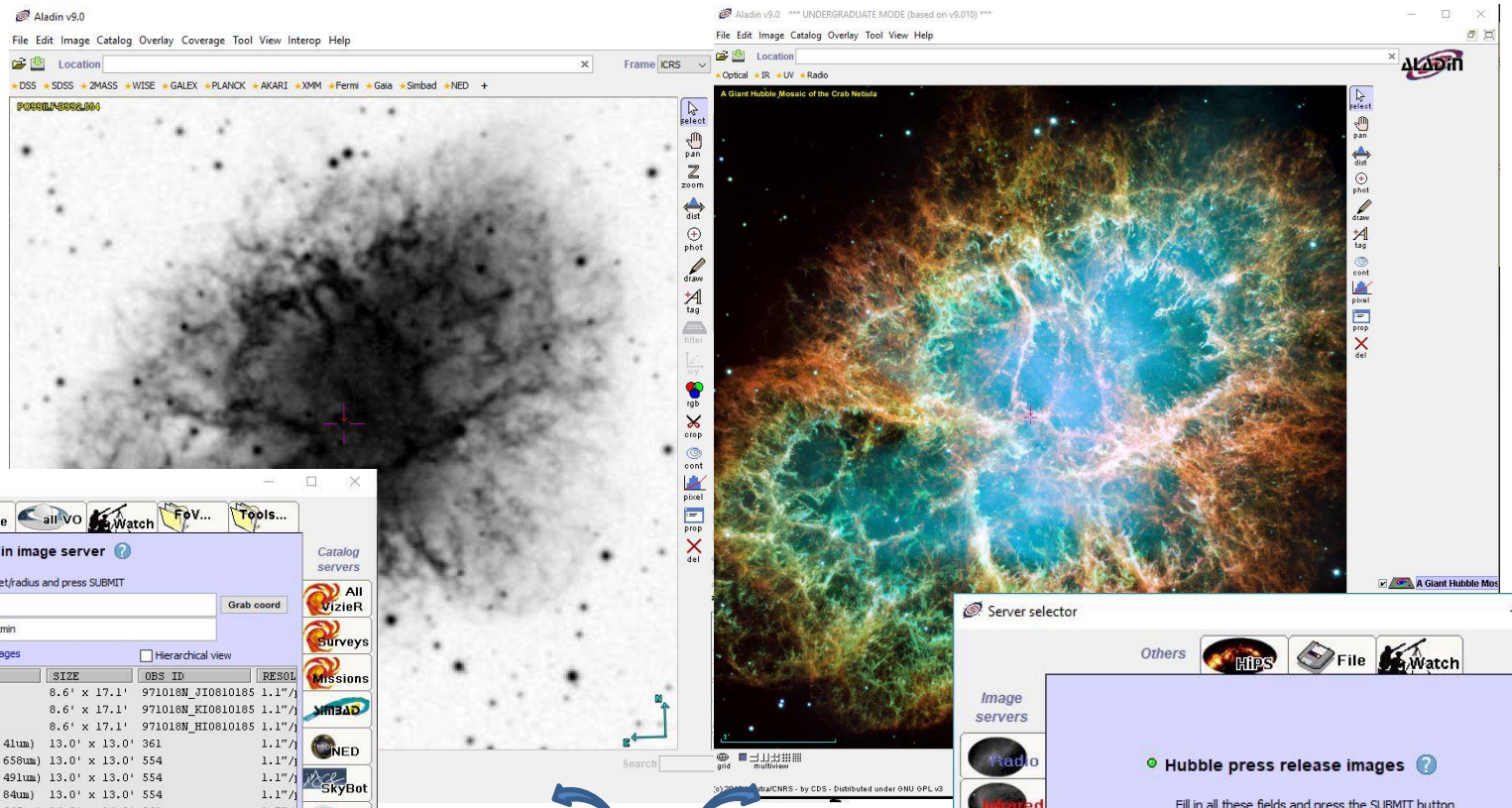
VO 4 Edu and Euro-VO

How:

- Astronomical data from professional archives
- Software tools adapted from the researchers' version
- Examples of use including step-by-step guides
- VO schools for teachers and activities in the classroom

Important: feed-back <-> product improvement cycles

Software tools



Examples of Use

EURO VO AIDA Astronomical Infrastructure for Data Access

DISTANCE TO THE CRAB NEBULA

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Information and contacts: **http://vo-for-education.oats.inaf.it - iafrate@oats.inaf.it**

Within this use case you learn about supernovae, exploding or exploded stars. In particular you will use information on the Crab Nebula (the 1054 aD supernova registered by Chinese astronomers) to derive its distance: an example of how some very important information may be gained from very simple arguments and geometry.

If used in the classroom this use case requires a very basic knowledge of the relation between angles and sides of triangles. If used in more advanced classes it may be a good demonstration of the power of trigonometry.

1 Introduction

The Crab Nebula (M1) is a supernova remnant observable in the constellation of Taurus. The bright supernova "SN1054" that originated the remnant was recorded by Chinese and Arab astronomers in 1054 A.D.
The fact we know the year of the explosion allow us to compute the expansion rate of the gas shell, and then, by comparison between angular and real dimensions of the nebula, obtain its distance.

2 The Crab Nebula

In visible light, the Crab Nebula consists of a oval-shaped mass of filaments that are the remnants of the progenitor star (fig. 1).

Fig. 1: Optical image of the Crab Nebula.

At the center of the nebula lies the Crab Pulsar, a rotating neutron star, which

edit -> user preferences -> profile -> undergraduate.

Restart Aladin in order to validate the new configuration.
Open the server selector window:

File -> Load astronomical image
-> Aladin image server

In the field "target" enter "M1" and press "submit". The list of available images appears (fig. 2): look at the dates of the images and load in Aladin the most recent one (taken in 1998).
We use this Crab Nebula image in the next step, when we will compute its projected angular size.

Now we need only to know the year the image has been taken. We calculate the time passed since the explosion (1054):

$$(1998 - 1054)\ \text{yr} = 944\ \text{yr} = 2.97 \cdot 10^{10}\ \text{s}.$$

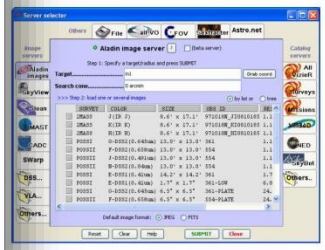


Fig 2: The server selector window with the list of available image.

We multiply this time by the velocity and obtain the linear size (the radius) of the nebula:

$$R = 2.97 \cdot 10^{10}\ \text{s} \cdot 1500\ \text{km/s} = 4.46 \cdot 10^{13}\ \text{km}.$$

5 Angular size of the nebula

In order to compute the angu
the nebula we use the tool "dis
a vector from the center of the
the outermost visible part.
The outer parts of the nebul
faint, so we adjust the
distribution by increasing the
the image.
The center of the nebula ma
the pulsar (marked on the imag
distance vector start from the
end it in the farmost region of
you can see (probably in the
angle of the image).
The modulus of the project
distance vector ranges betwee
2.8'. In the case of fig. 3 it is

$$r = 2.66'.$$

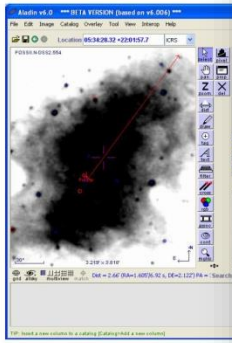


Fig. 3: the distance vector for com
angular size of the nebul

6 Distance to the Crab Nebula

We now have both the linear and the angular size of the nebula: by comparing them we can compute its distance from us.
In order to obtain the distance in parsec we have to express the sizes in the proper units: the linear size in parsec and the angular size in radians.

$$1\ \text{pc} = 3.085 \cdot 10^{16}\ \text{m}$$

$$R = 4.46 \cdot 10^{13}\ \text{km} = 4.46 \cdot 10^{16}\ \text{m} = 1.44\ \text{pc}.$$

Then

$$1\ \text{rad} = 206264''$$

$$r = 2.66' = 159.6'' = 7.73 \cdot 10^{-04}\ \text{rad}.$$

We finally compute the distance to the Crab nebula:

$$d = R / r = 1.44 / 7.73 \cdot 10^{-04} = 1860\ \text{pc} = 1.86\ \text{kpc}.$$

The correct value of the distance to the Crab Nebula is about 2 kpc (6500 light years), very close to the value obtained with our simple analysis. In particular our value is a little low because of the approximations of our procedure.

7 Hubble Space Telescope images of the Crab Nebula

Aladin can access the archive of the Hubble Space Telescope and load its amazing images.
In order to load the images of the Crab Nebula open the server selector, then in the left column select "Hubble press release image", in the field "target" enter "M1" and press "submit".

The list of available image
4).

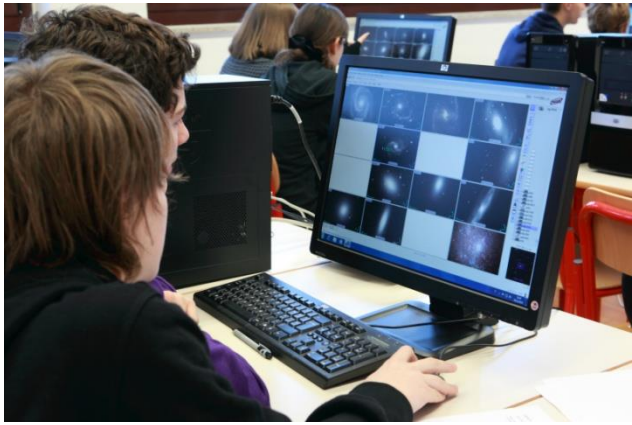
Fig. 4: Images of the Crab Nebu
Hubble Space Telescope

For example, if you want to
you can load the image
rays and optical images
Nebula" (fig. 5).

Fig. 5: Combined X-Rays and O
the Crab Nebula

By loading "A Giant Hubble
Crab Nebula", you can se
image of the entire nebula (

Teachers and students



VO 4 Edu on a global scale

The International Virtual Observatory Alliance (IVOA) establishes the

Edu Interest Group

based on the VO 4 Edu experience (2013)

IVOA and the Edu IG

Long term goal:

widest global distribution of VO tools, data and practices in support of astronomy teaching in schools and universities

IVOA and the Edu IG

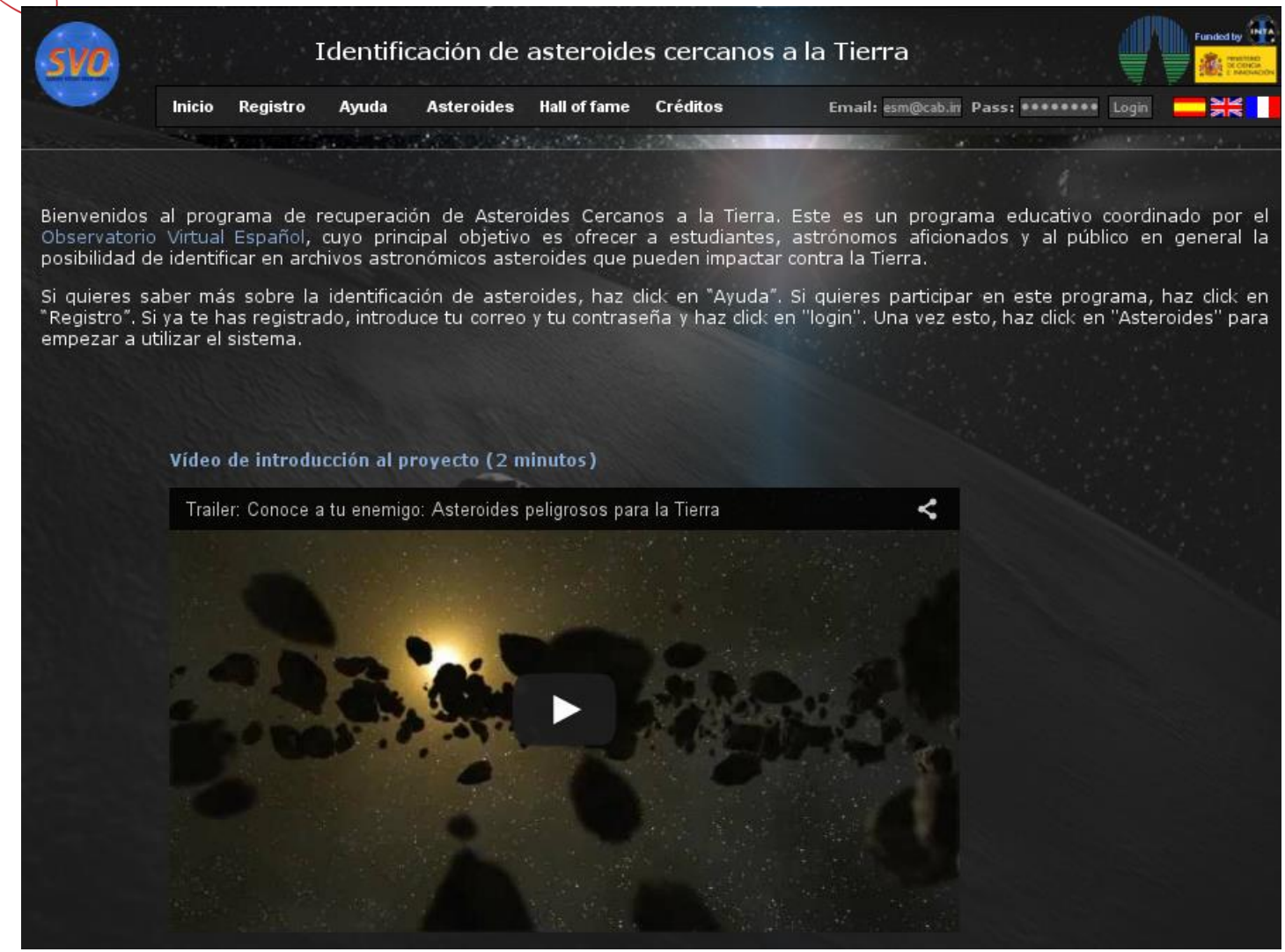
From the Interest Group's Rationale (2013):

- Astronomy is undergoing major transformations with large investment into few cutting edge instruments with extreme technical specifications and performances.
- A risk of "big science": astronomy may become too remote from the public.
- It is of the utmost importance for astronomy to develop strong and extended roots within the society. VO is a most effective resource with its excellent educational tools and knowledge base, deriving directly from professional astronomy.

Future of VO 4 Edu

- Continue development, updating and diffusion
- Systematic approach to translations

and: VO for citizen science projects



http://www.laeff.cab.inta-csic.es/projects/near

Astron. Nachr. / AN 335, No. 2, 142 – 149 (2014) / DOI 10.1002/asna.201311888

Precovery of near-Earth asteroids by a citizen-science project of the Spanish Virtual Observatory

E. Solano[1,2,⋆], C. Rodrigo[1,2], R. Pulido[1,2], and B. Carry[3]

ELSEVIER

Icarus

Volume 268, April 2016, Pages 340-354

Spectral properties of near-Earth and Mars-crossing asteroids using Sloan photometry

B. Carry [a, b], E. Solano [c, d], S. Eggl [a], F.E. DeMeo [e, f]

Future of VO 4 Edu

Last but not least,

Now VO is in IAU's DEPO WG

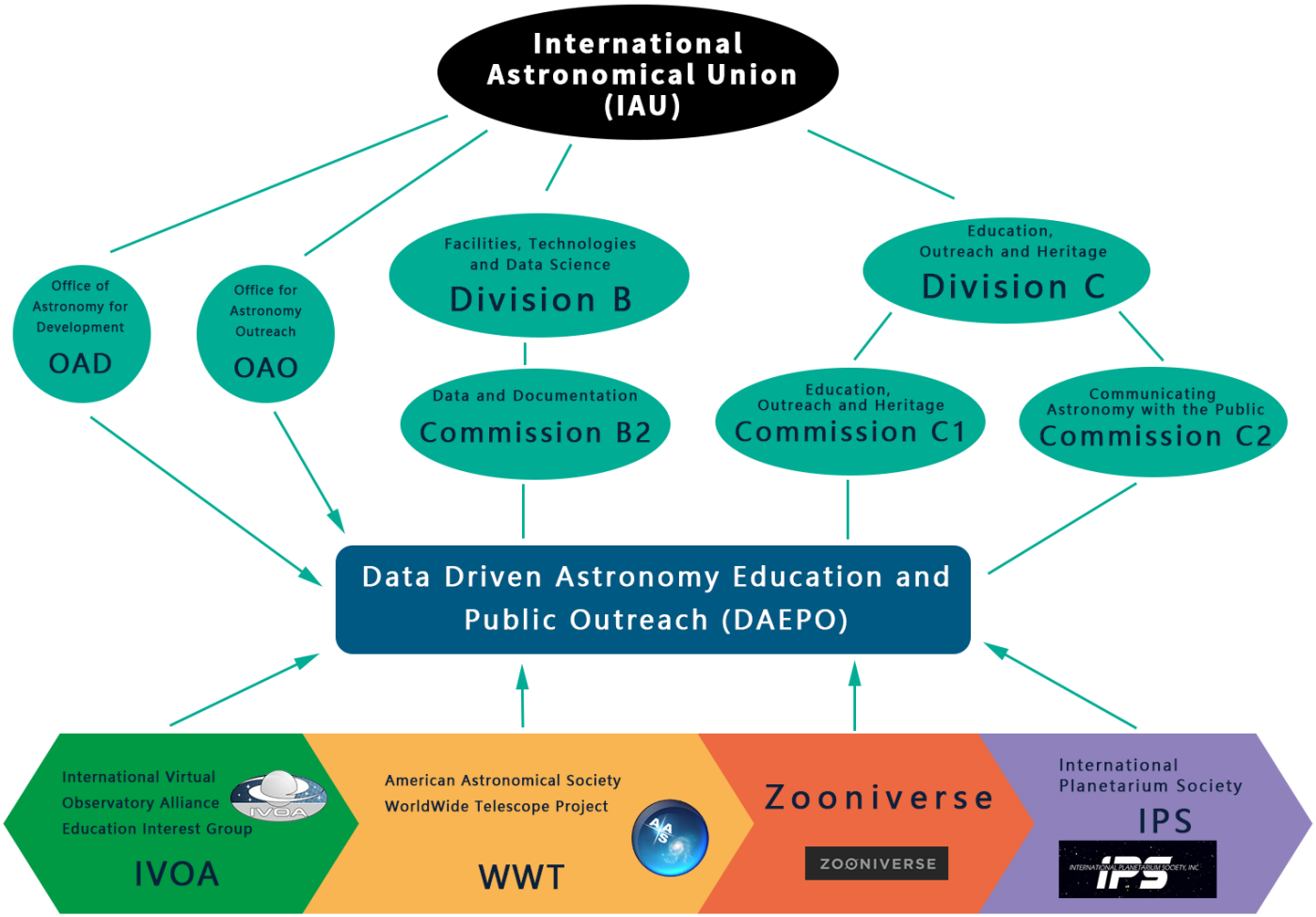
IAU Inter-Commission B2-C1-C2 WG

Data Driven Astronomy Education and Public Outreach

Chenzhou CUI, Chair

Author: Chenzhou CUI

DAEPO Ecosystem



Author: Chenzhou CUI

Conclusion

EPO is an ethical requirement in a society based on consensus

and

a lot has been accomplished

but

the road from the telescope to the classroom is all but short, downhill and well paved.