VO SCIENCE

Enrique Solano
LAEFF / Spanish Virtual Observatory

- What is VO Science?, why? and why now?
- The role of Science in the VO projects.
- VO Science cases.

Astronomy in the XXI century

- The advances in technology (telescope design and fabrication, large-scale detector arrays, computing capability) are now permitting to explore the Universe in a multi-parameter space.
  - The inherent limitations in wavelength range, area coverage, depth or resolution of small datasets can be overcome.
  - more complete and less biased understanding of complex astrophysical phenomena.
- The advances in computational capabilities have provided the means to make, for the first time, direct comparisons between complex theoretical calculations and large, statistically significant observational databases.

BUT...

Astronomy in the XXI century

– The progress in the scientific exploitation has not kept pace with the exponential growth of these vast new datasets.

– This situation is demanding changes in the "classical" methodology.

The classical way of doing Astronomy

I. Get the data

New data

Archive data

II. Reduce and analyze the data locally.

MIDAS

IDL

IRAF
Image Reduction and Analysis Facility

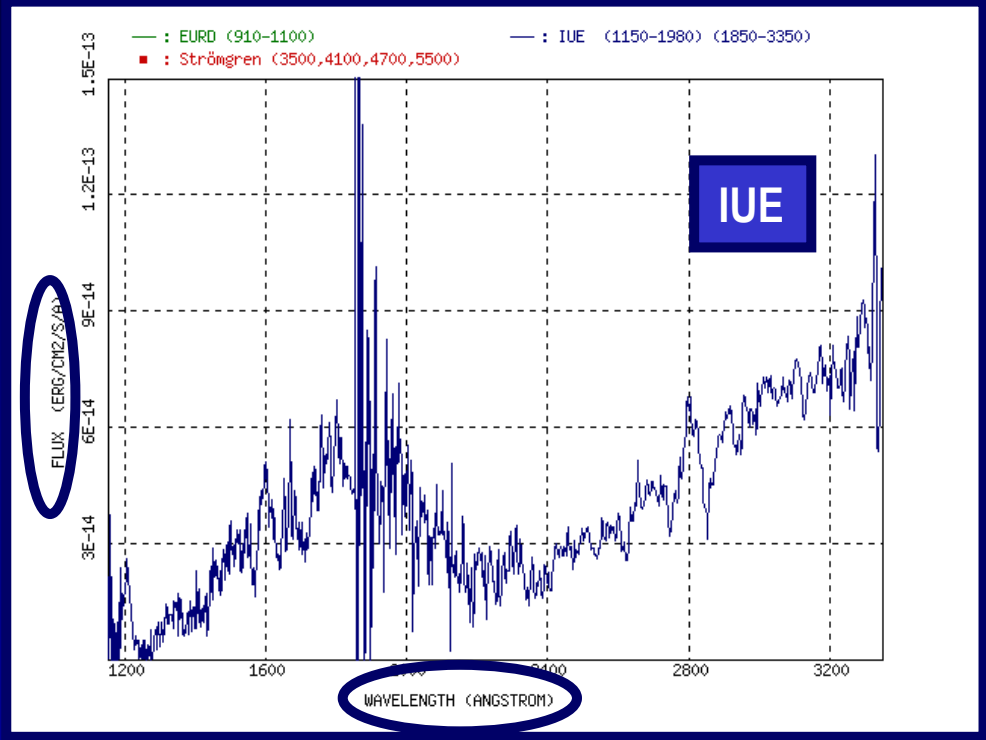
VO: a complementary approach

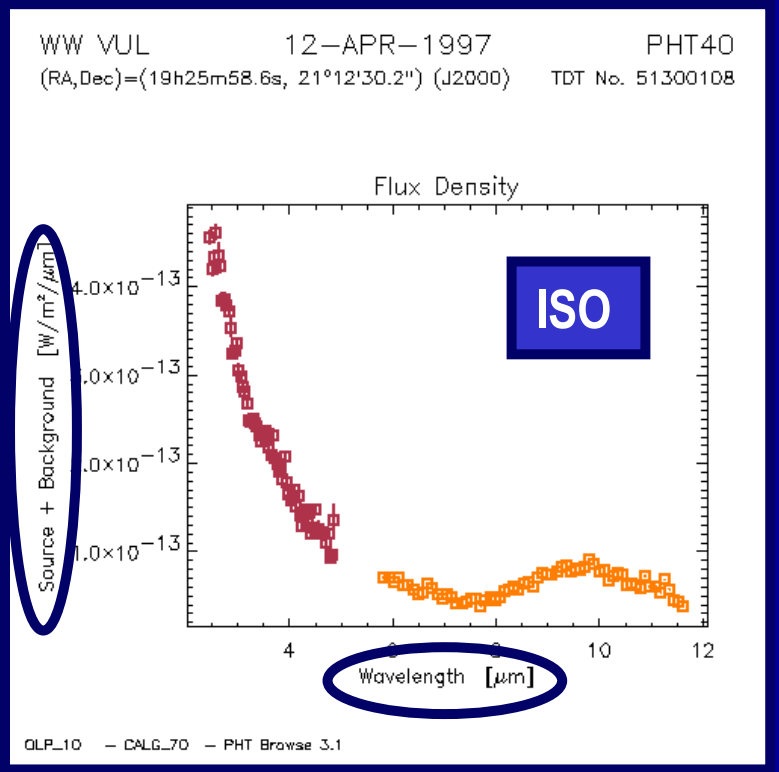
- The classical method has demonstrated to be quite inefficient when dealing with problems that require:
  - ✓ Interoperability among data services and/or
  - ✓ Management of large volumes of data.

An interoperability problem: Building of SEDs

➲ Research multiple sites (assuming I already know about all the useful sites)

➲ Retrieve all the spectral information available for a given object to build its spectral energy distribution."





UBVRIJHK

- Wavelength: Å + μ
- Magnitudes!!!

Radio

- Wavelength: mm
- Flux: mJy

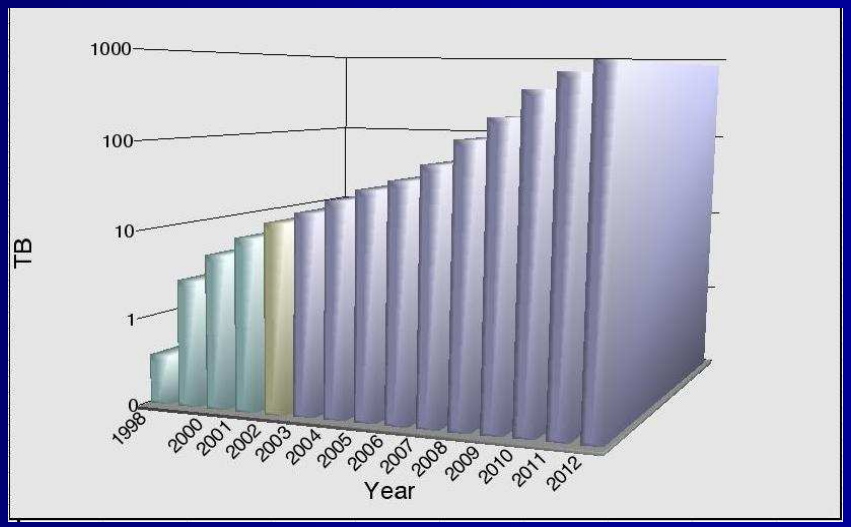
The solutions provided by VO to solve the interoperability problem

- Agree and build standards.
  - Standard semantic: UCDs
  - Standard access protocols
  - Standard output formats
  - Standard data models
  - Automated discovery tools (registries)
- Uptake of standards by the data services.
- Development of a federation of astronomical data centres ("data grid").

"large" really means LARGE

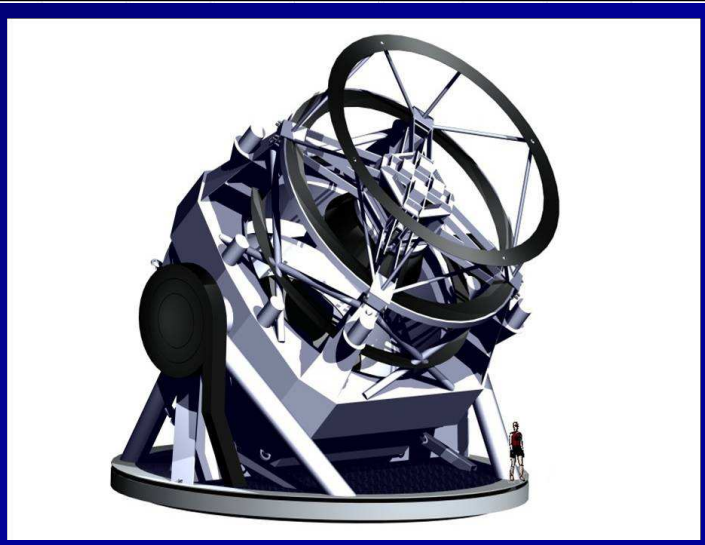
➢ Archive data are dramatically increasing.

✓ *ESO/ST-ECF Science Archive Facility holdings (x100 increase in the next 7 years)*



✓ *LSST*

- It will scan the visible sky every few nights.
- Few TB/night. A factor of 1000 larger than current surveys.



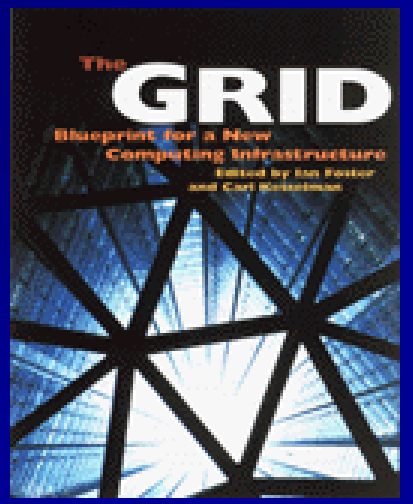
The solution provided by VO to solve the problem of the data avalanche

- Move from download to service paradigm
  - Leave the data where it is.
  - Remote operations on data (search, analysis, etc).
  - Ship the results not the data.

Requirements on data centres: computing

- Local resources:
  Supercomputers,
  PC farms

- Distributed computing:
  the GRID



Requirements on data centres: analysis tools

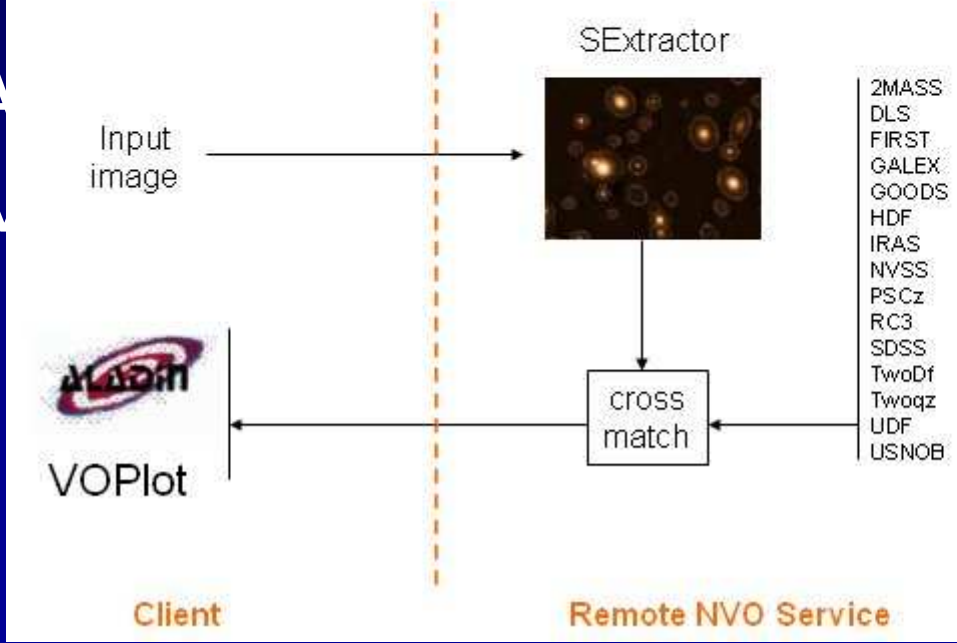
- I… …ctor, Hy…
- A… av…

Project Title: Web Enabled Source Identification with Cross Matching (WESIX)

Upload images to SExtractor and cross-correlate the objects found with selected survey catalogs.

Contact Information: Simon Krughoff
simon at phyast.pitt.edu

Website:
http://nvo.phyast.pitt.edu/wsext



2.- The role of Science in the VO projects

- VO is driven by science and it will become a science driver.

- Although technology enabled, the Virtual Observatory must not be seen as a technological project only. Its final goal is to produce better, new and more efficient science.

- Showing the science community the potential benefits of VO was a major and early task in the VO projects (NVO, AstroGrid, AVO,…).

→ Creation of Scientific WGs to provide advice to the project.

→ Elaboration of lists of VO use cases with a clear definition of the science requirements.

The AVO Science Working Group

- The Astrophysical Virtual Observatory is committed to the pursuit of science with Virtual Observatory tools through

  → scientific demonstrations on a yearly basis,

  → science papers, and

  → a Science Reference Mission.

The AVO Science Reference Mission

What is the Science Reference Mission (SRM)? The SRM is a definition of the key scientific results that the full-fledged, Phase B, EuroVO should be able to achieve when fully implemented. It will consist of a number of science cases, with related requirements, against which the success of the EuroVO will be measured.

Contents:

SRM document

- final version (.pdf)

SRM Cases

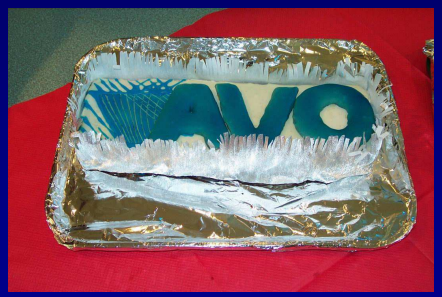
- Circumstellar Disks (.txt)
- Intermediate Velocity Clouds (.txt)
- Which Star will go Supernova next? (.txt)
- Initial Mass Function (low masses) (.txt)
- Initial Mass Function (high masses) (.txt)
- Low and intermediate mass stars contribution to the ISM (.txt)
- Galaxy Formation and Evolution (.txt)
- Build-up of Supermassive Black Holes (.txt)
- Formation and Evolution of Galaxy Clusters (.doc)
- Correlation of CMB background, radio/mm, and optical/NIR Galaxy Surveys (.txt)

The AVO Scientific Demonstrations

• Annual scientific demonstrations based on more and more complex demonstrators.

J.Bank03

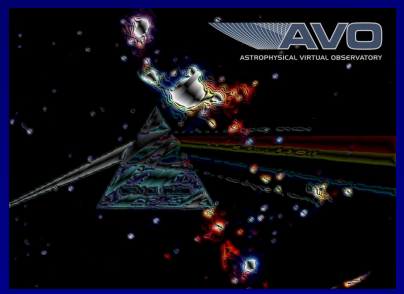
AVO First light



• Multi-waveband analysis of HDF(N)

Garching04

AVO 1st Science



• Obscured quasars
• Star-Forming regions in the Milky Way.

ESAC05

Final Demo.

• AGB-PN transition
• Star formation histories in galaxies.

From Demo to Real Science

- Extragalactic case: Discovery of 31 type 2 QSOs.

→ First refereed astronomical paper enabled via end-to-end use of VO tools and systems:

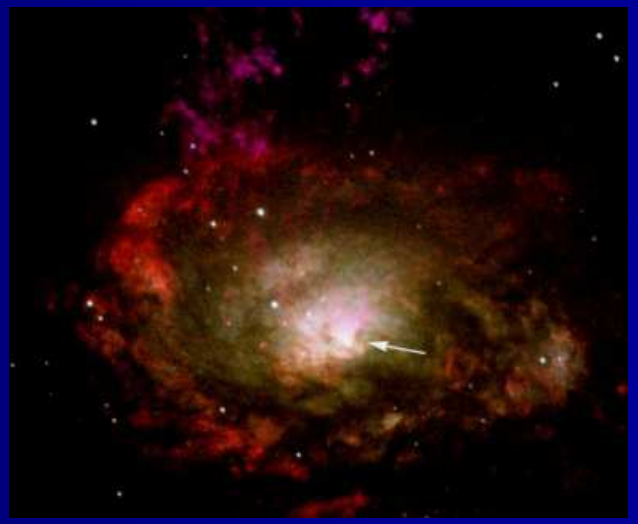
A&A 424, 545–559 (2004)
DOI: 10.1051/0004-6361:20041153

Astronomy & Astrophysics

Discovery of optically faint obscured quasars with Virtual Observatory tools

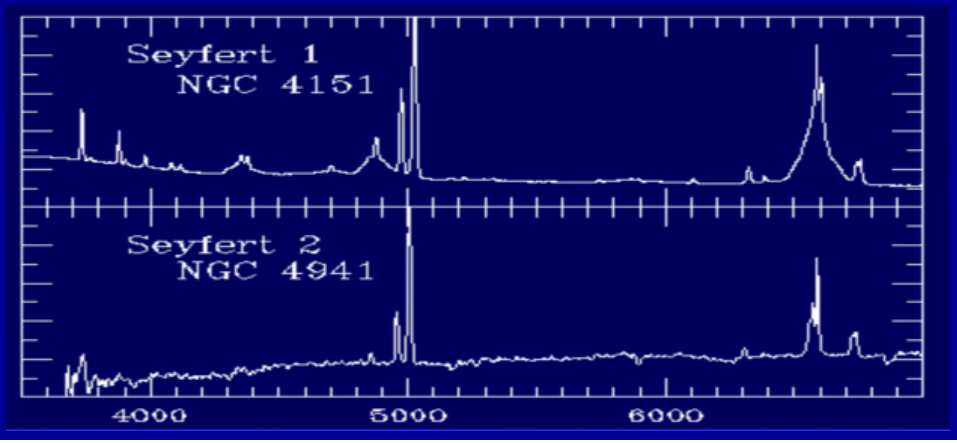
P. Padovani[1], M. G. Allen[2], P. Rosati[3], and N. A. Walton[4]

Seyfert galaxies



- **Seyfert galaxies:** spiral galaxies exhibiting bright nuclei and emission lines.

- **Seyfert type 1's** are characterised by broad permitted lines (e.g. HI, HEI, HEII), with widths of up to 10000 km/s, and narrow forbidden lines. **Seyfert type 2's** have narrow forbidden and permitted lines with widths between 300 and 1000 km/s.



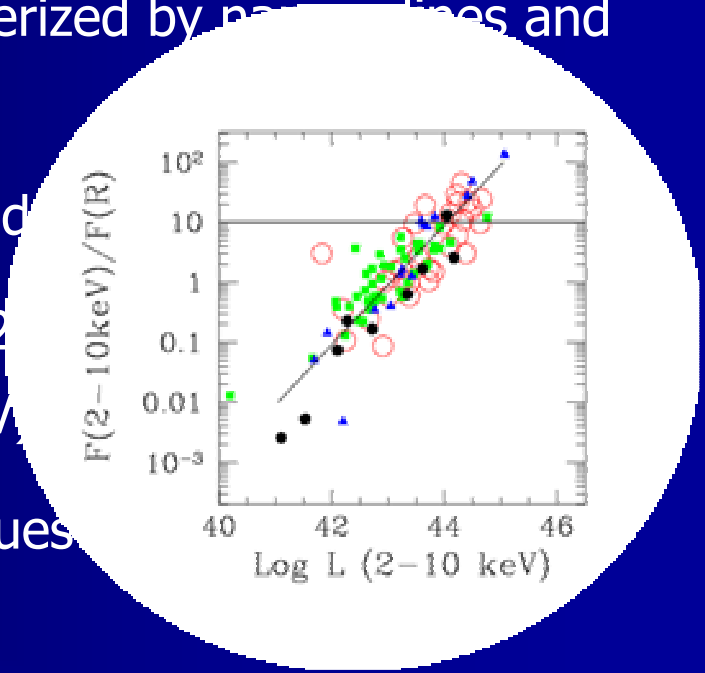
Unified model for AGN

- All AGNs are the same. They consist of a supermassive central black hole surrounded by an accretion disk and jets.

- Differences are due to different viewing angles. If the AGN is observed edge-on, only the narrow-line regions, located further away from the nucleus are observed (type 2). If, on the contrary, our line of sight lies close enough to the axis of the torus, we can peer directly through the hole of the donut (type 1).

Discovering type 2 quasars

- Seyfert 2's high-power counterparts. Characterized by n… lines and hard X-ray emission (Lx > 1e44 erg/s).

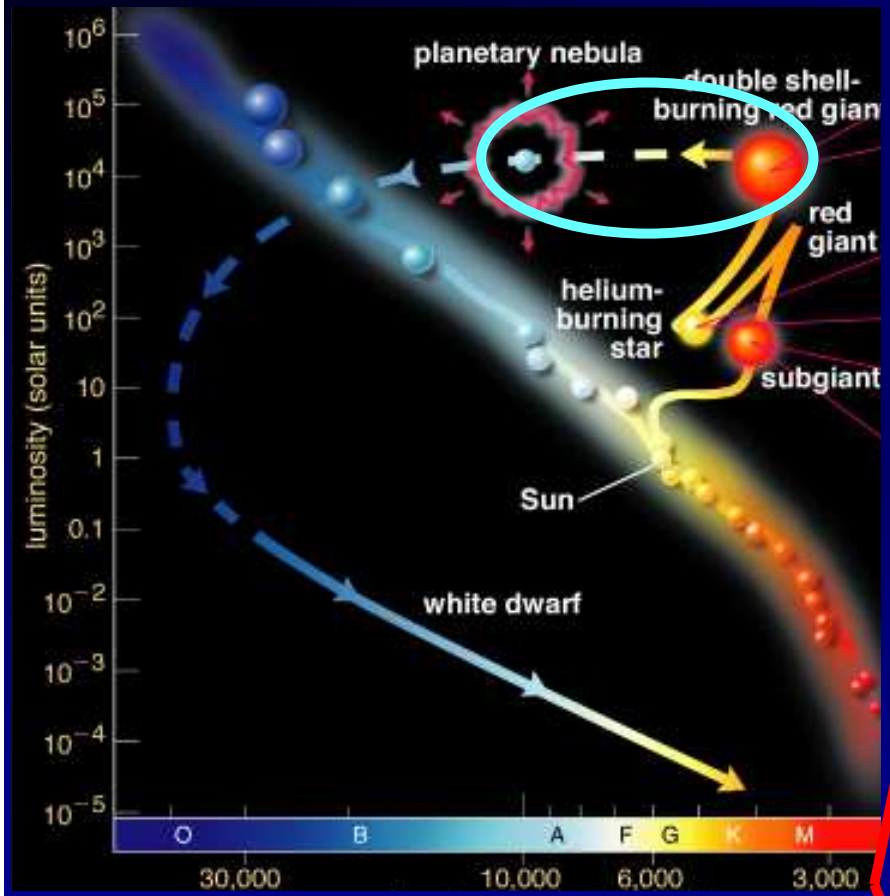


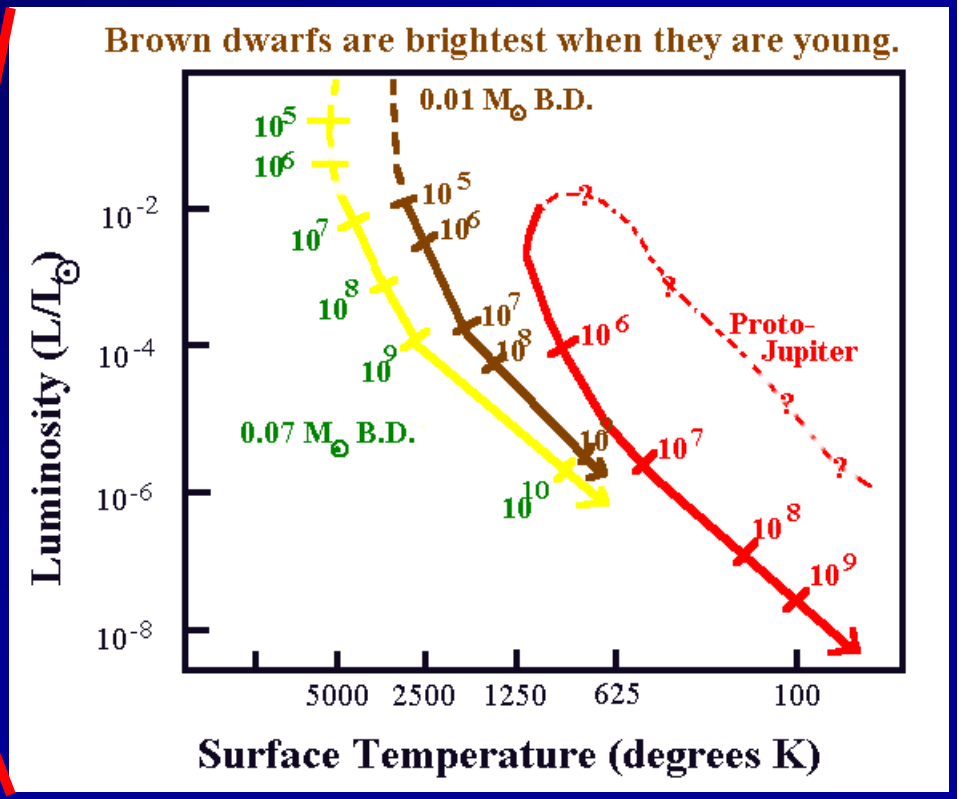
- Data: X-ray catalogue for the two GOODS field…
- Filtering: HR ≥ -0.2 for absorbed sources → 2…

  HR=(H+S) / (H-S); H = (2.0 - 8.0 keV…
- Cross-matching with the GOODS ACS catalogues… counterparts → 168 matches.
- Data manipulation: X-ray power for unidentified sources derived from:

  Log L (2-10) = log f(2 – 10 keV) / f(R) + 43.05 (Fiore 2003).
- Results: 31 new QSOs 2 (only 9 sources previously known).

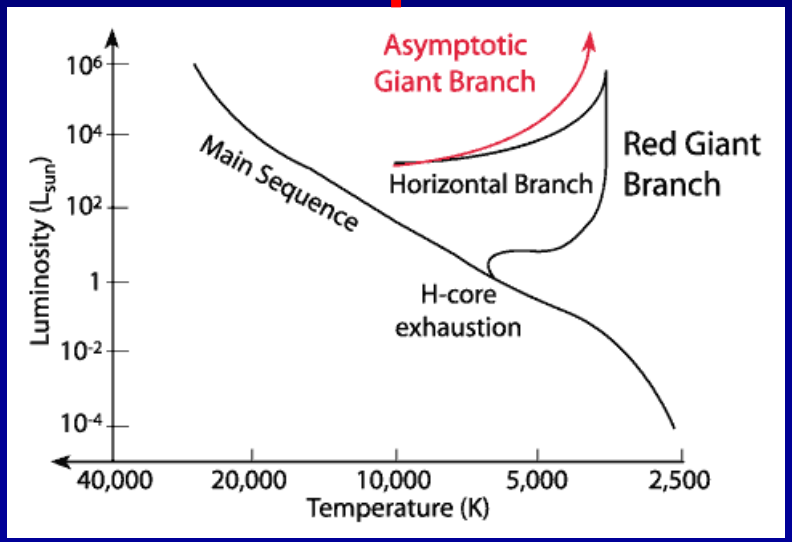
Some other (stellar) VO Science Cases

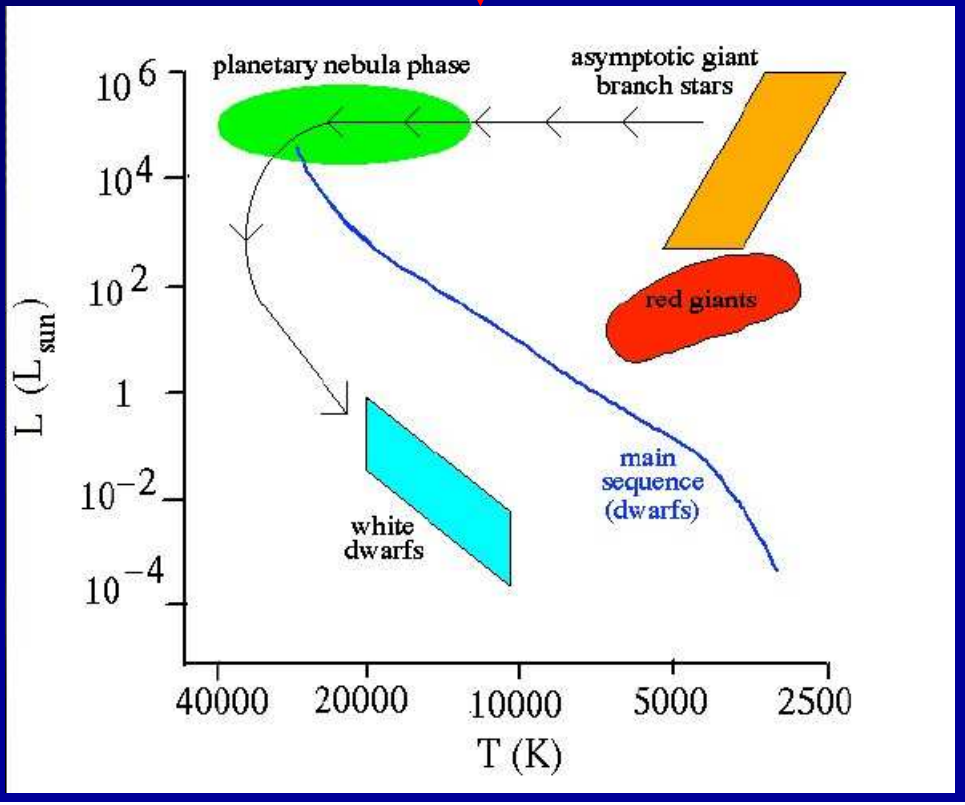




AGB stars to PNe

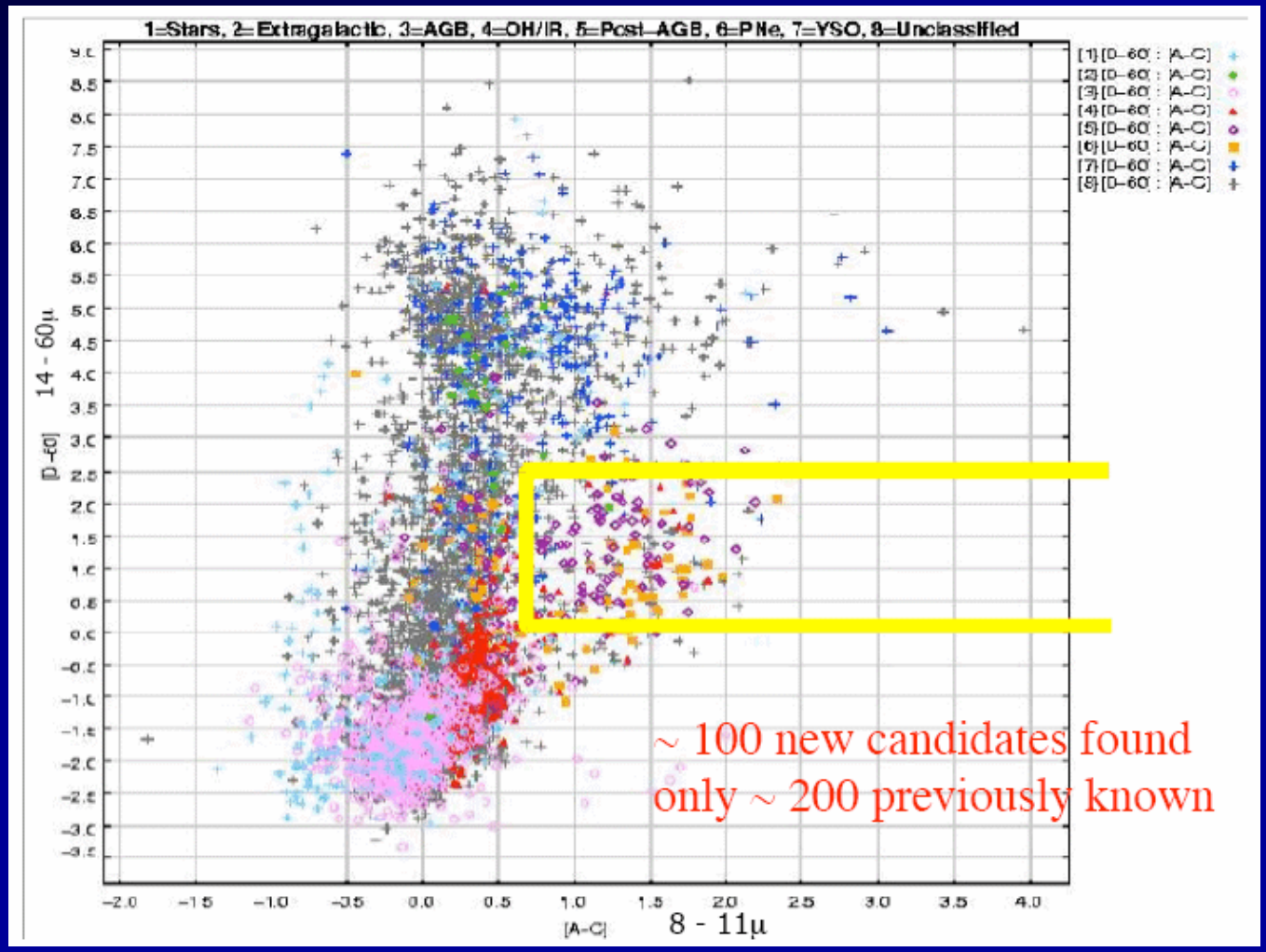
- Short transition times → Few objects in this phase.
- Stellar case for the AVO Demo 2005 (García Lario, Bayo, Sierra)
- Many are heavily obscured in the optical by thick CS envelopes consequence of strong mass loss → Need for systematic surveys using IR data: MSX and IRAS catalogues.
- Late evolutionary stages of low and intermediate mass stars.
- GOAL: Identification of new candidates in the transition source.





AGB stars to PNe (II): Workflow

- Selection criteria: |b| ≥ 2 deg.
- Cross-matching with SIMBAD.
- Column manipulation
- Cross-matching with IRAS



AGB stars to PNe:

VO gain: Efficiency

A spectroscopic atlas of post-AGB stars and Planetary Nebulae selected from the IRAS Point Source Catalogue. *

O. Suárez[1], P. García-Lario[2], A. Manchado[3,4], M. Manteiga[5], A. Ulla[6], and S.R. Pottasch[7]

Abstract. We present low-resolution optical spectroscopy, finding charts and improved astrometric coordinates of a sample of 254 IRAS sources showing far infrared colours similar to those of well-known planetary nebulae. 106 sources are classified as post-AGB stars, 21 as "transition sources", and 36 as planetary nebulae, some of them strongly reddened. The large majority remained unidentified in the literature or were poorly known by the time when this spectroscopic survey started, some 15 years ago. Among the rest of sources in the sample, we were also able to identify 38 young stellar objects, 5 peculiar stars and 2 Seyfert galaxies. Up to 46 sources in our spectroscopic sample were found to show no optical counterpart, most of them are suggested to be heavily obscured post-AGB stars, rapidly evolving in their way to become planetary nebulae. A preliminary analysis of the distribution of post-AGB stars and PNe in the IRAS two-colour diagram is presented, as well as of their galactic latitude distribution. We also analyse the spectral type distribution of the post-AGB stars observed.

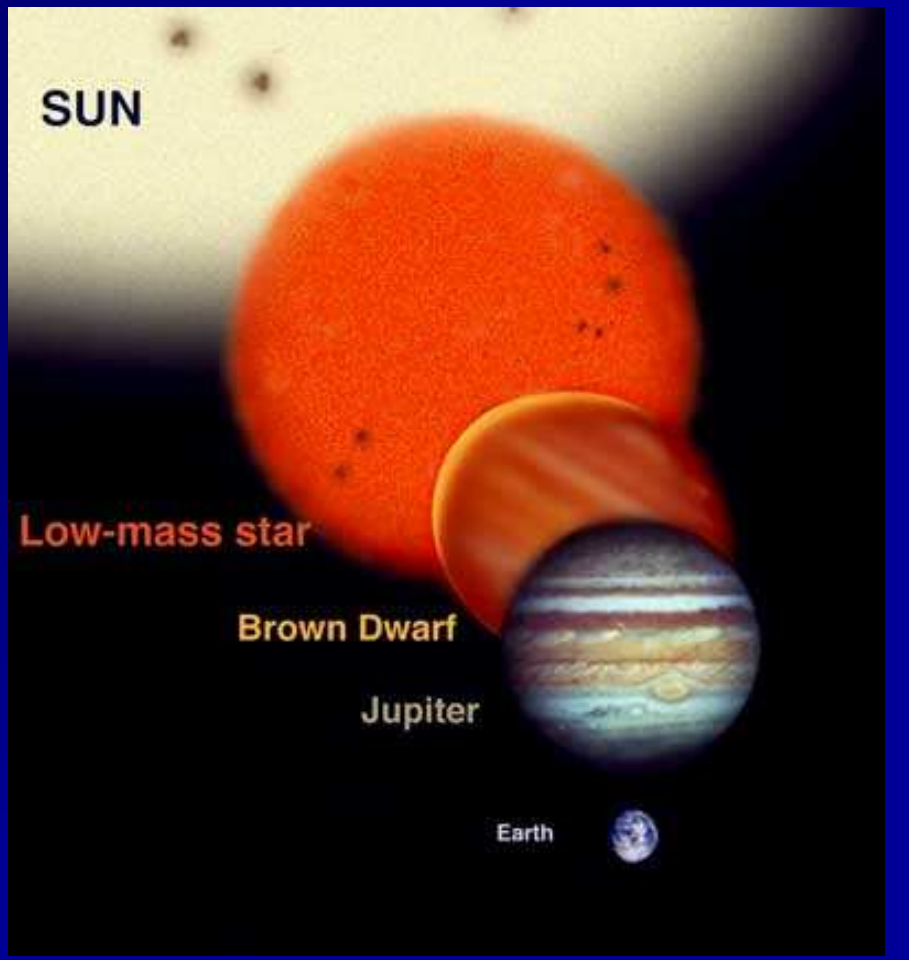
Key words. Planetary nebulae – stars: AGB and Post-AGB – infrared radiation – stars: mass loss

Searches for rare objects: discovery of brown dwarfs

- Part of the SRM Case: "The IMF within 1 kpc: from planetary to stellar masses".

- Astrogrid Top Ten: "Census of all brown dwarfs within 1 kpc".

- NVO Demo 2003.



Discovery of brown dwarfs

• A key question in the area of star formation is the form of the stellar mass function at the lower end, i.e., what is the contribution of brown dwarfs to the stellar mass budget.

• Up to 30% of all stars within 10 pc remain unknown (Henry et al. 1997, AJ, 114, 388)

• The situation is even worse at substellar masses. The BD density is twice higher than that for MS stars (Reid et al. 1999, ApJ 521, 613). However, only a handful of T dwarfs are known at less than 10 pc from the Sun compared to more than 300 stars within the same volume.

• This problem can be alleviated using the sky surveys available to identify BD through a combination of colour and proper motion information.

Discovery of Brown Dwarfs

NATIONAL VIRTUAL OBSERVATORY

PROJECT

Standards
Software & Services
Publications
Prototypes

Internal
Logos

ABOUT NVO

What is the NVO?
Science Objectives

COMMUNITY

Discussion Lists
International VO
VOForum
Metadata (NCSA)
Other Links

PEOPLE

Contact Us
Personnel

Brown Dwarf Search Science Prototype: Real-Time Cross Matching of Large Catalogs

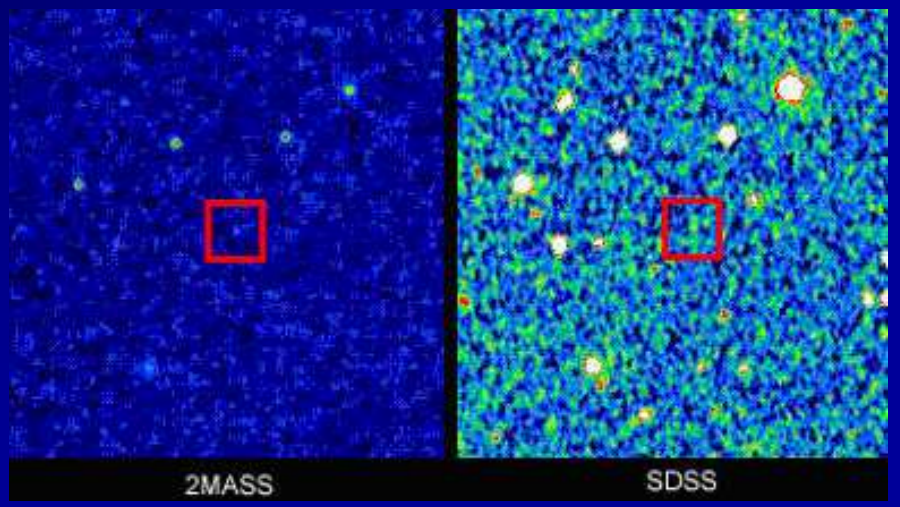
Scientific Motivation The search for brown dwarfs has been revolutionized by the latest deep sky surveys. A key attribute to discovering brown dwarfs is the federation of many surveys over different wavelengths. Such matching of catalogs is currently laborious and time consuming. This matching problem is generic to many areas of astrophysics.

Data Resources

- Sloan Digital Sky Survey (SDSS) Early Data Release (15 million objects)
- 2-Micron All Sky Survey (2MASS) 2nd Incremental Point Source Catalog (162 million objects)

What the VO Brings Today, doing the matching of these two large datasets is user-intensive and is replicated by many different users. Also, the correlation of these two datasets can take years of CPU time if not done correctly. The NVO brings two key aspects to

- **Search criteria:** z-only detections matching J-only detection with z-J > 2.75.



Spanish Virtual Observatory

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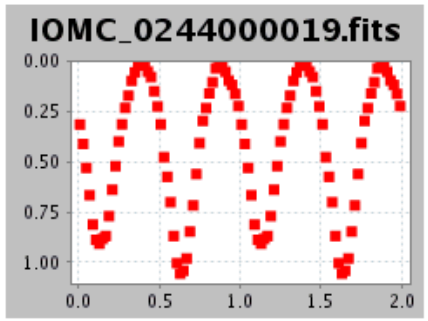
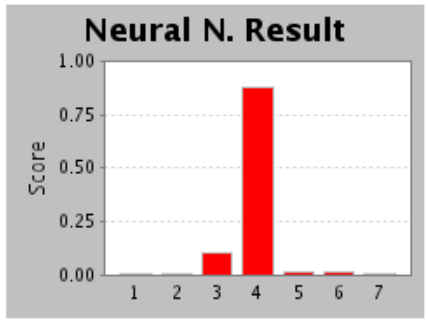
User: Enrique Solano Márquez Log out

Neural Network Characterization





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2	Type 2	.00000
3	Type 3	.10133
4	Type 4	.87626
5	Type 5	.01120
6	Type 6	.01569
7	Type 7	.00069

EGSO: European Grid of Solar Observations

First EGSO Use Case

Flare Impulsive Phase: Energy Deposition (Single Event Case)

Author: Ester Antonucci

Objective:

Determine the energy released in the solar atmosphere during a flare impulsive phase. This implies the identification of the site (s) of the flare-enhanced emission and the measurement of thermal and non-thermal emission in the relevant wavelength regions.

Second EGSO Use Case

Emergence of an Active Region

Author: J. Aboudarham

Objective:

Follow an active region from the time it appears in the photosphere to its appearance in transition region and corona in order to study its evolution.

International Outer Planet Watch (IOPW)

✓ Organization of astronomers and planetary scientists devoted to coordinate and encourage observations of the giant planets, their satellites, and magnetospheres, from the Earth and from space, with an emphasis on time-variable phenomena.

- Coordination of 24-hour observations.
- Rapid sharing of information.
- Provide a long term context for "snapshots" that in situ spacecraft, like Galileo and Cassini, provide.
- Six subdisciplines: Io torus, atmospheres, satellites, magnetopsheres and radio emission, aurora, laboratory & theory, Titan, Uranus & Neptune.

PVOL
Planetary Virtual Observatory & Laboratory

- ✓ Started in September 2004
- ✓ Large collection of images taken with ground-based telescopes and almost all the times by amateur astronomers.

http://www.pvol.ehu.es/getVOTable?TARGET=Uranus

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Skybot

- ✓ Pre-calculated ephemeris database of the Solar system bodies (asteroids, planets, satellites, comets)
- ✓ From 1840 (first astronomical photography) to 2019 (end of GAIA)

Conclusions

- ✓ VO Science is not science fiction. It already exists.
- ✓ VO is not only for people interested in handling large volumes of data. (e.g. "give me all spectra of A-type stars in a given range and with resolution > R).
- ✓ VO is not replacing the scientist (sorry, there are not plans to implement a "write paper" button) but making them much more efficient. VO will help astronomers to do what they really want to do: ask scientific questions, interpret the data and publish the results rather than hunting and gathering data.
- ✓ The successfulness of VO from the scientific point of view strongly depends on the interaction with the scientific community. The participation of the community at different level must be encouraged as much as possible.