A contribution to the Astronet Science Vision from the Network for UltraViolet Astronomy *(NUVA)*

Topics relevant to Panel C

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NUVA URL:
www.ucm.es/info/nuva/

What is NUVA?

- The Network for UltraViolet Astronomy (NUVA) was promoted by a group of European astronomers to build a roadmap for future UV facilities in Europe.
- NUVA objectives are to involve the community to identify:
  - The key science objectives that need UV data
  - The requirements for future UV instrumentations.
- NUVA is funded within the Networking activities of OPTICON by the European Commission Framework Program VI.

Why the UV range is important

- Richness of experimental data for study of plasma with temperatures from 3,000-300,000 K.
  - Unmatched by any other domain
- **Electronic transitions** of most abundant molecules, atoms and ions, observed in this range
  - E.g. H_2, OH, or CO: also the most sensitive to the presence of large molecules such as the PAHs.
- Most sensitive **spectral tracers of diffuse baryonic matter**
  - HI Lyα in the nearby Universe and HeII Lyα at $2<z<9$

The UV roadmap first steps

The NUVA people, *including also non European scientists*, produced the book:

"***Fundamental questions in astrophysics: Guidelines for future UV observatories***" Astrophysics and Space Science, Vol. 303, Kluwer-Springer (2006)

The identified Major Science Issues requiring UV Data are:

I. Re-ionization of the Universe

II. The early evolution of the Sun & its interaction with the young planetary disk

III. Atmospheres of extrasolar planets

Panel C

Other Science Issues relevant to panel C

- **Planets and the origin of life**:
  - Planetary atmospheres, auroral variability, comets
- **ISM and Formation and Evolution of Stars**:
  - Hot stars atmospheres (and abundance determination) from white dwarfs to hypergiants
  - Cool stars atmospheres and magnetic dissipation phenomena
  - Interacting binaries and accretion physics
  - Circumstellar material and shells in warm environments, jets, shocks and HH objects
  - Chemical abundances in supernovae remnants and in the early phases of supernovae explosions
  - The warm and hot components of the ISM

Panel C: How do stars form?

The role of clusters. The current consensus is that most stars form in very dense environments ranging from about 40 stars/pc^3 to 10^7 stars/pc^3 in extreme cases, where the Solar neighbourhood has a density of 1 star/pc^3. Starbursts (10^7 stars/pc^3) are extremely bright and allow observational probing of star-formation over cosmological epochs. The physics of the formation and early evolution of such objects is largely unknown, but is crucially important for the stellar distribution in galaxies and for their morphological appearance, as well as for the formation of intermediate black holes and their transport to the centres of galaxies where they may merge (§ 3.1, 3.4).

- UV imaging observations of starbursts are relevant in understanding the violent star formation processes in galaxies, the interaction between the stellar clusters and the interstellar medium, and the variation of the IMF.
- High-spatial resolution spectra are needed:
  - to isolate the light from the center to the disk in the UV luminous galaxies found by GALEX at $z = 0.1 - 0.3$.
  - to isolate the galactic, the stellar and the interstellar components of several ions to perform a quantitative characterization of the outflows.

Panel C: What do we learn by probing stellar interiors?

A better understanding of stellar activity would certainly improve our understanding, and perhaps our prospects for predicting, Solar activity (§ 5.3).

From the recommendations

- The continuing availability of X-ray observatories for deep surveys and detailed spectroscopy of individual objects will be an essential asset to study the origin of stellar activity through all phases of stellar evolution.

From the recommendations – panel D

- High-resolution multi-object spectrographs at 4–8 m class telescopes to routinely monitor a large number of Solar-like stars to test theories of magnetic and velocity fields on stars that rotate faster or slower than the Sun and/or show different amount of magnetic flux;

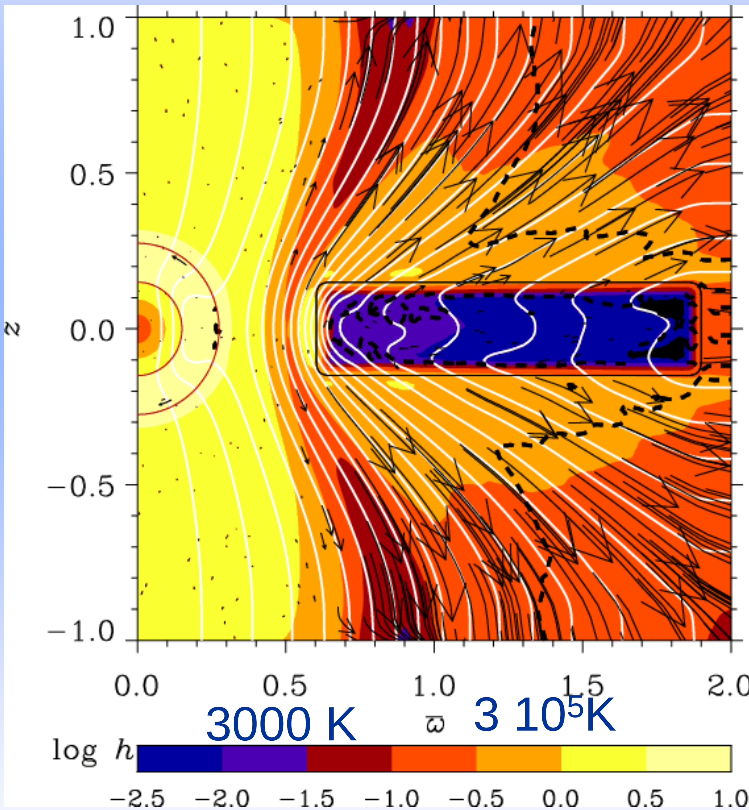
UV relevance to stellar activity

The UV range is unique as it permits the study of cool star atmospheres from the chromosphere to the corona. Recent techniques have used the **hydrogen Ly*α* line profile** to study, for the first time, the wind from solar like stars through its interaction with the interstellar gas.

- **A 2m class UV telescope** with monitoring capabilities would allow to get:
  - **spectra** of the faint objects out to at least 150 pc, including, e.g. the important **young galactic clusters** α Per and the Pleiades, as well as the key TW Hya **star-forming region;**
  - **images** of a **compact galactic cluster** or **PMS candidates in a star-forming region** to scrutinize for flares and rotational modulations of active regions .
- A larger aperture telescope (**from 4 to 6m**) would permit the study of the plasma dynamic and the chromospheric – transition region structures of fainter magnetic active stars, like brown dwarfs and stars in an larger sample of clusters. UV **high resolution spectroscopy** ($R \geq 100{,}000$) is mandatory to study **solar-like stellar winds**.

Panel C: How do planetary systems form and evolve?

The role of UV radiation



0.06 UA

0.2 UA

The inner part of younger planetary system is illuminated by the strong UV radiation field produced by the star and the accretion–outflow engine.

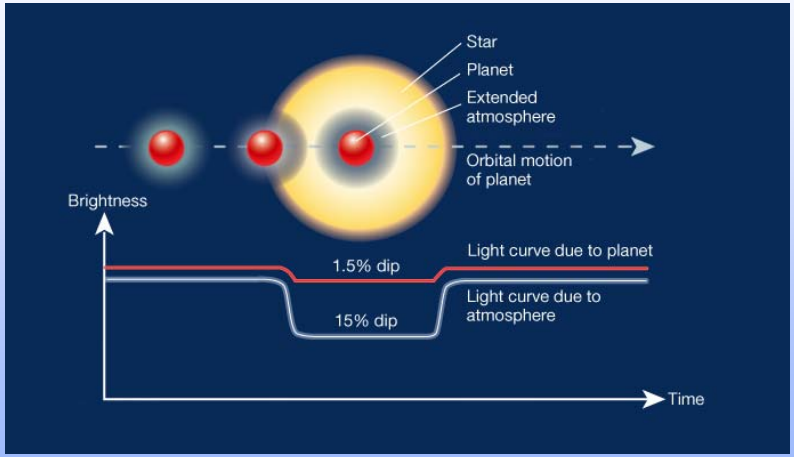
UV radiation and disk chemistry

- UV effects on planetary formation
  - UV radiation important photochemical agent… accelerates formation of large organic molecules
  - Evolution of embryonic planetary atmospheres
  - Vertical structure of disk
  - Planet-disk decoupling time
- Young planetary systems
  - detection of volatiles released by dust, planetesimals & comets through the stellar wind/disk interaction.
  - CO from comets

Panel C: How do we tell which planets harbour life?

The first direct detection of the atmosphere of a giant hot planet orbiting a star outside our Solar system was performed by HST when the planet passed in front of its parent star, allowing to see light from the star filtered through the planet's atmosphere. This unique observation demonstrated that, under fortunate conditions, it is possible to measure the chemical composition of exoplanet atmospheres even with current instruments.

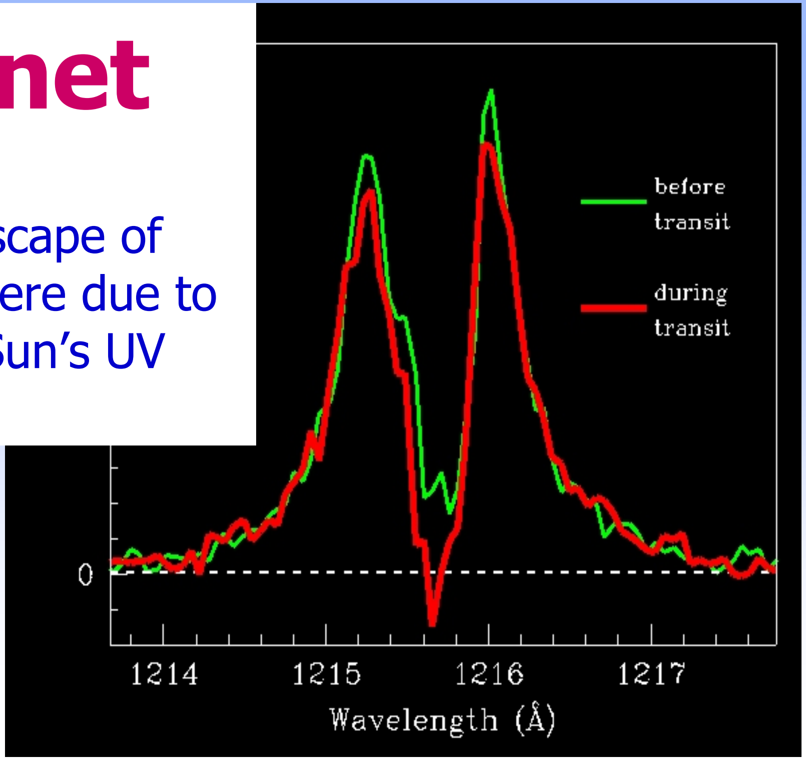
HD 209458b
Evaporating atmosphere



- Vidal-Madjar et al. (*Nature* 422, 143, 2003) detected a 15% change in the Lya depth during transit of **HR20945**
- Extended a
mass loss r
- By means o
observation
et al. (2004) found also **C** & **O** in the HD 209458b atmosphere.

Ocean planet

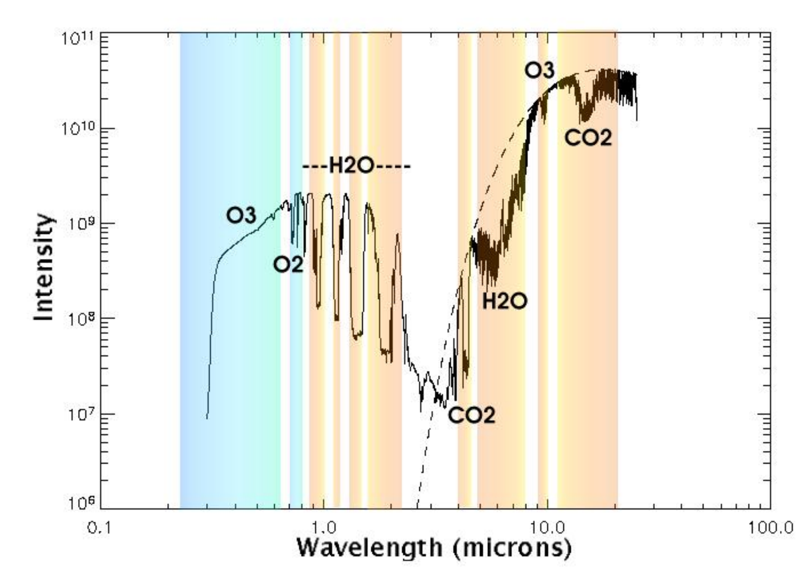
Like the hydrodynamical escape of the Earth primary atmosphere due to the heating by the young Sun's UV and X-ray flux.



Characterization of exoplanets atmospheres

The Hartley bands of O_3 are the main absorbers at 200–300 nm. O_2 has strong absorptions in the range 150–200 nm. CO has strong bands below 180 nm, and weaker Cameron bands from 180 to 260 nm.

- The **electronic molecular transitions** are several orders of magnitude **stronger** than the vibrational or rotational transitions observed in the infrared/radio range.



- These transitions can be **observed in absorption** provided there is a sufficiently strong UV background source.
- For this reason, **the observation of UV and optical absorption** when a planet transits its parent star **is intrinsically a powerful diagnostic technique to characterize the atmospheres of the inner** planets.
- This is especially true for studying small Earth-like exoplanets.

Recommendations from NUVA

- To ensure the **continuing availability of UV dedicated observatories** (2-m class in short time and 4-8m class for the future) for high resolution imaging and spectroscopy. This would be an essential asset to study:
  - Star formation and enviroment interaction (sturbursts)
  - Late stage of stellar evolution (e.g. SNe)
  - Stellar activity through all phases of stellar evolution
  - Accretion phenomena
  - Chemistry of the protoplanetary disk
  - Atmospheres of extrasolar planets.