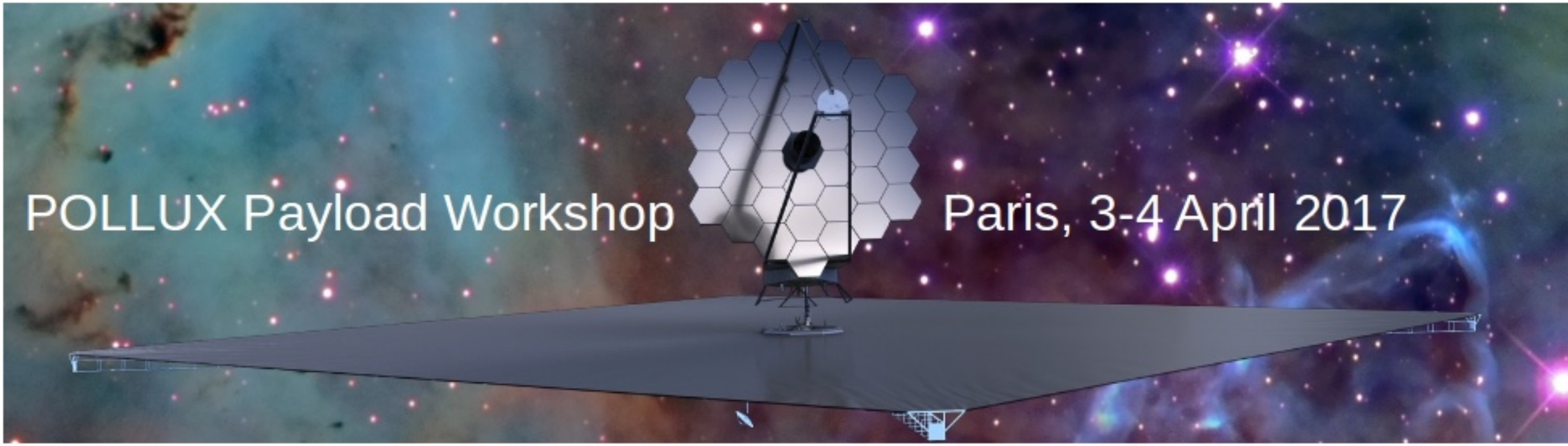
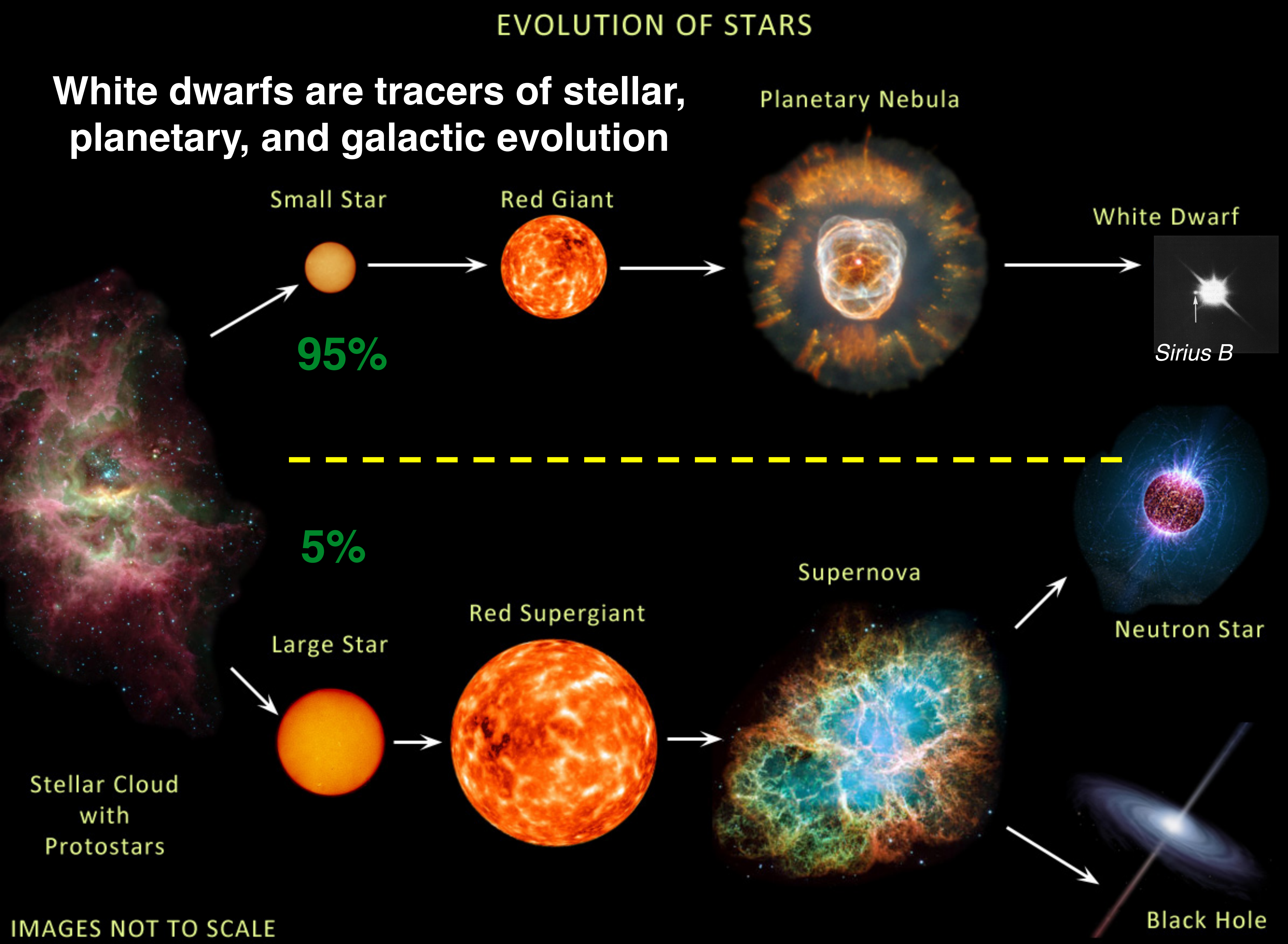


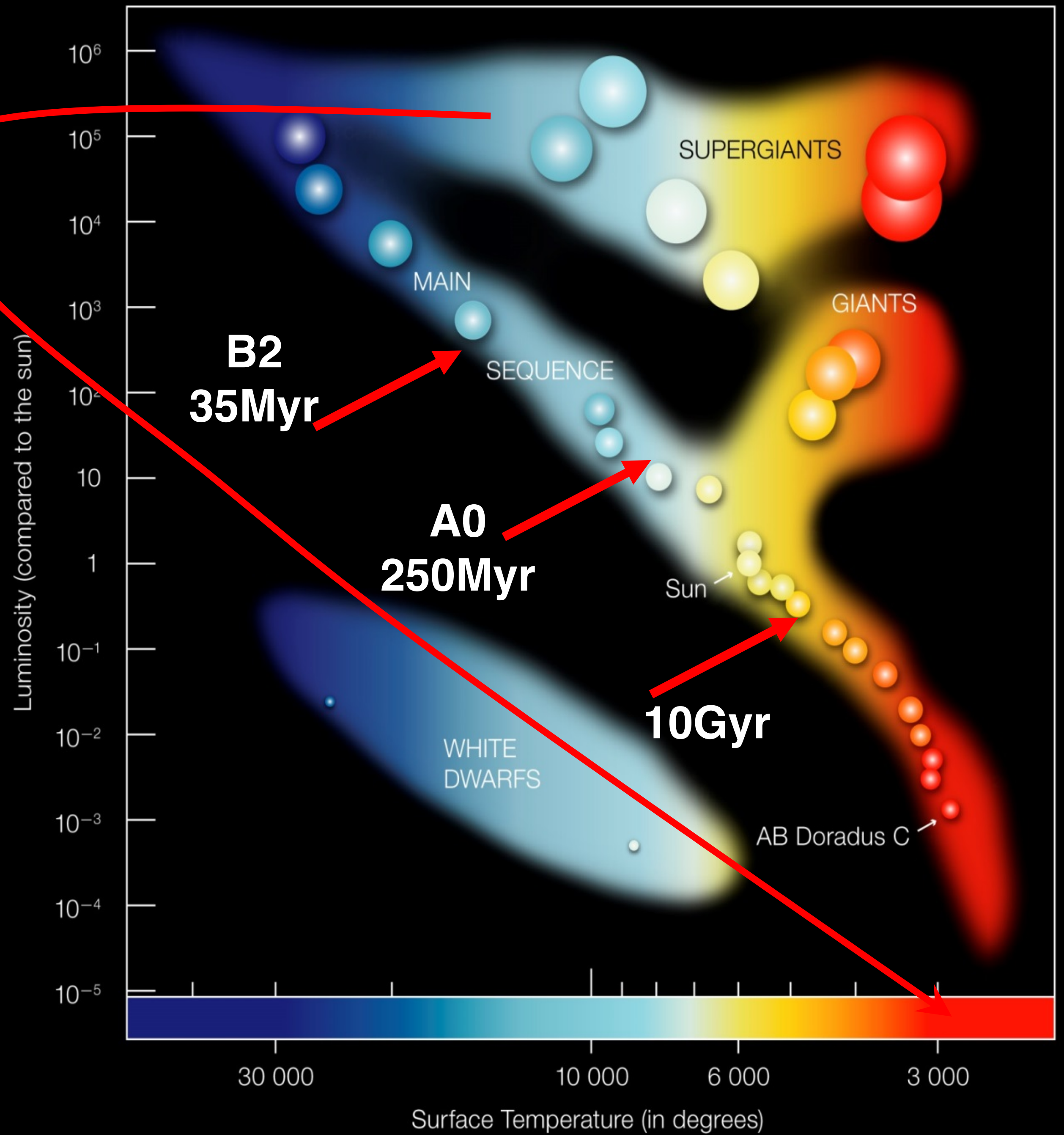
Science case for White Dwarfs

On behalf of B. Gaensicke, U. Warwick (UK),
M. Barstow, U. Leicester (UK),
S. Geier, U. Tübingen (G),
C. Knigge, U. Southampton (UK),
T. Marsh, U. Warwick (UK),
P.E. Tremblay, U. Warwick (UK),
K. Werner, U. Tübingen (G)

White dwarfs are tracers of stellar, planetary, and galactic evolution



Most stars with initial masses ≳ 1.5M⊙ are now white dwarfs



WDs are the remnants of all stars that have already left the MS

↓

Homogenous and complete sample of WDs can be used to measure the star formation history in the MW

Science topics as listed by the WG

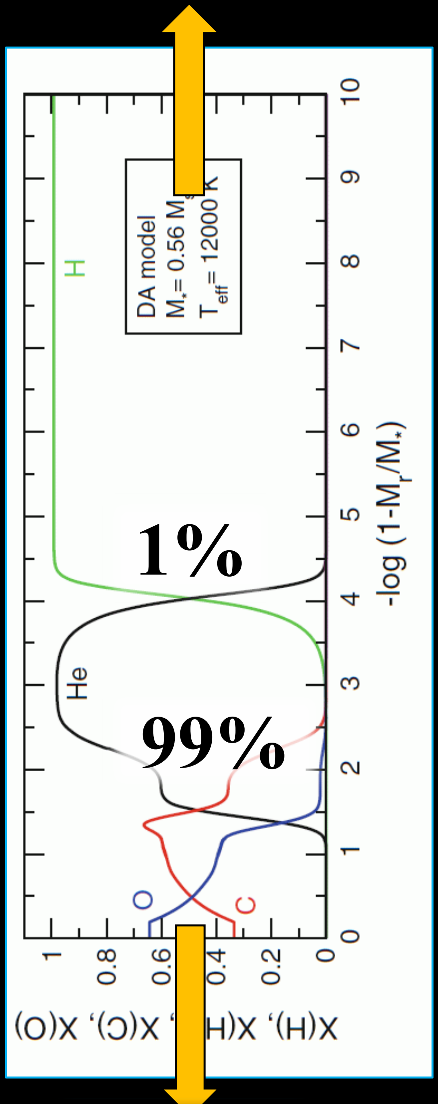
- Probing the local star formation history
- Measuring the bulk composition of exo-planetesimals
- The origin of magnetic fields
- The structure of electron-degenerate stars
- The progenitors of supernovae type Ia
- The physics of accretion discs

Fundamental questions :

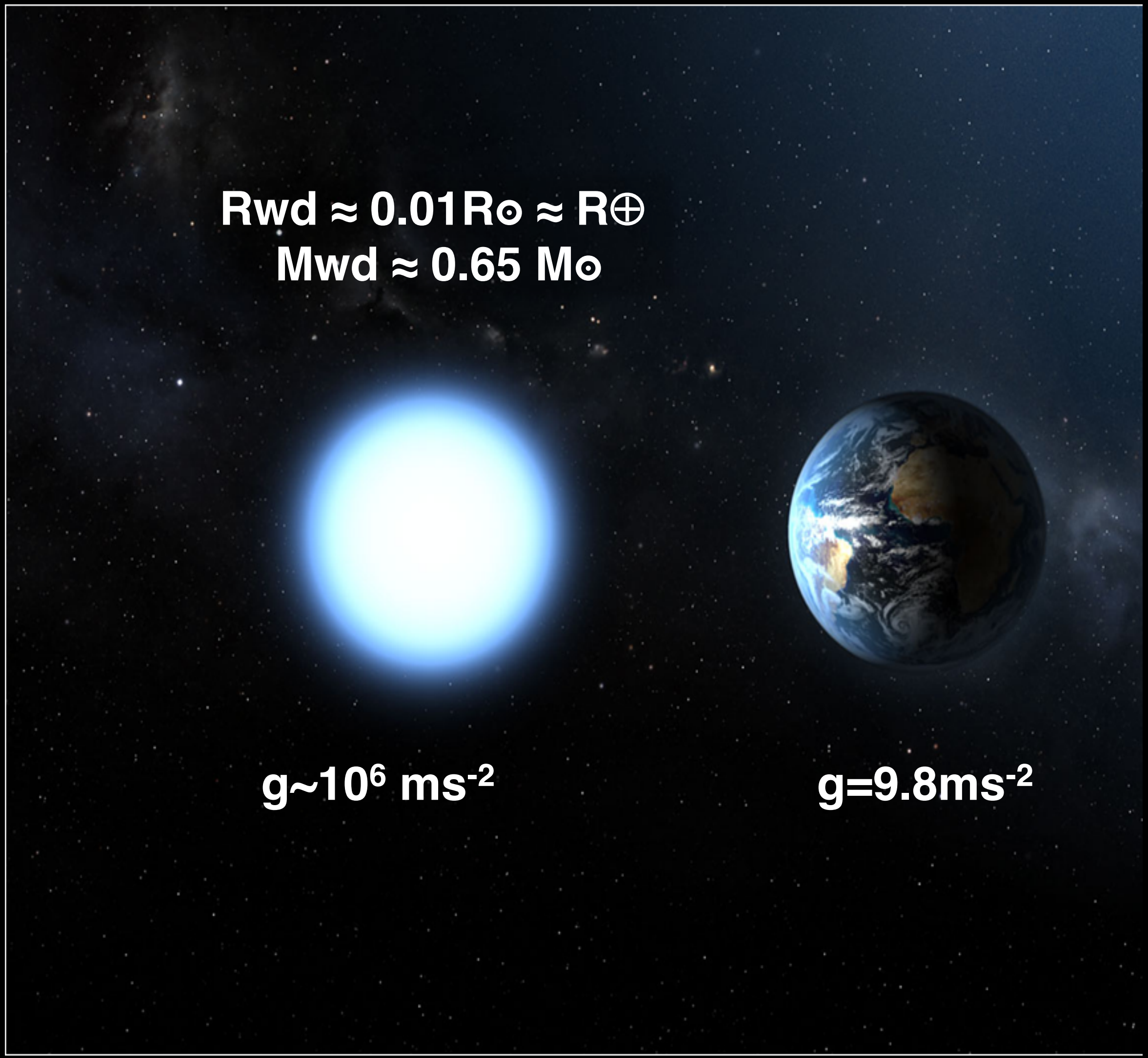
➢ **What is the structure of electron-degenerate stars?**

- Measure mass, radius, temperatures, cooling ages
- Probe the core composition, feedback on our understanding of nucleosynthesis

Pure H or He atmosphere



C/O core

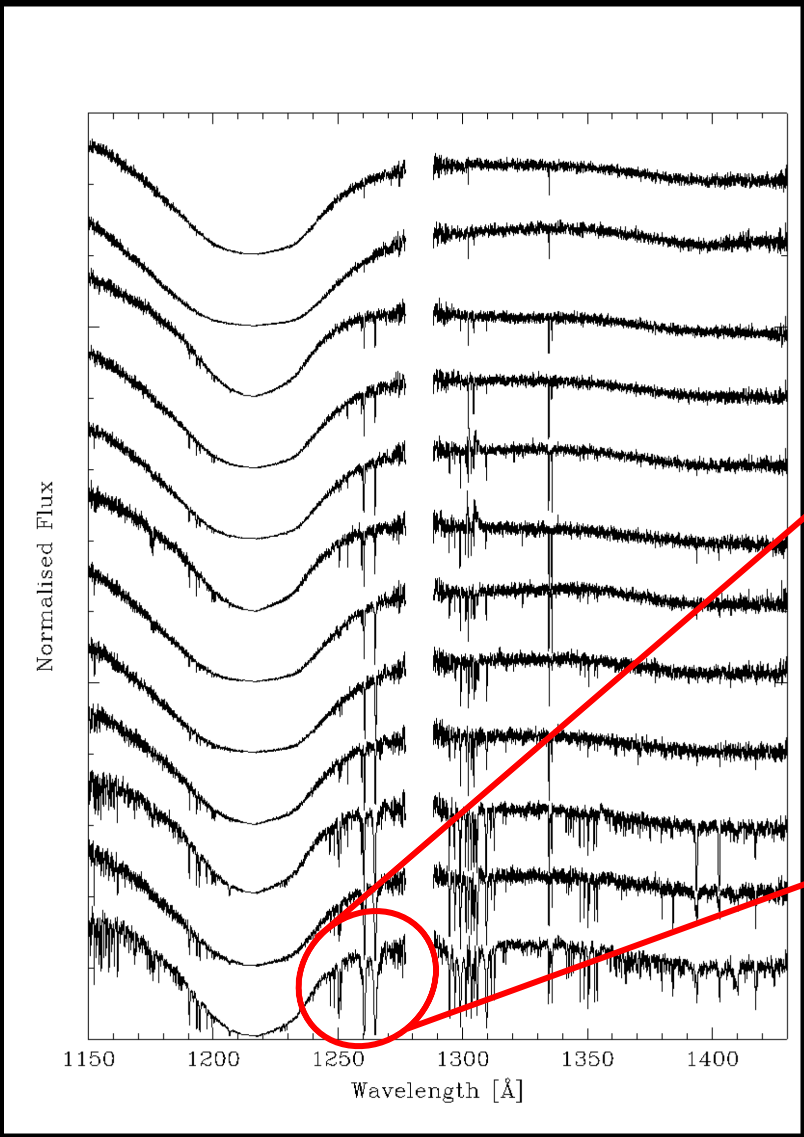


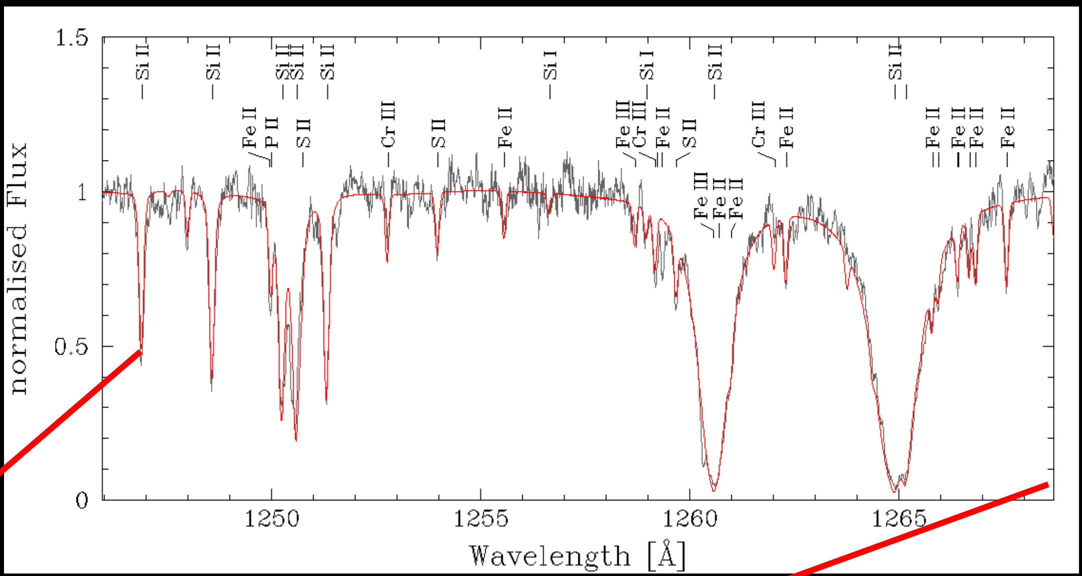
Althaus et al. 2010, A&A Rev 18, 471

Fundamental questions :

➢ **The bulk composition of exo-planets**

- Expand the sample of white dwarfs accreting planetary debris from a handful to ~100. Probe for variations in the bulk compositions. Is the solar system “normal”?
- Feedback into planet formation models
- Is there evidence for exotic outliers, such as carbon planets?





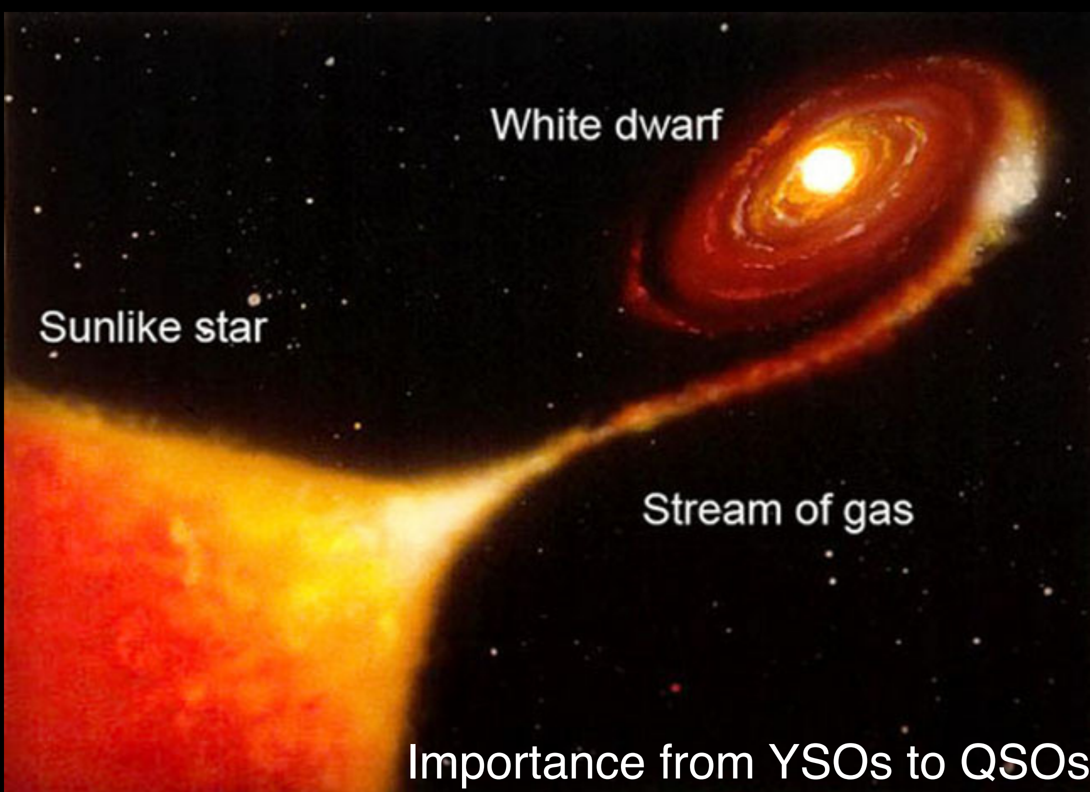
Rock forming elements
Volatiles
Core material

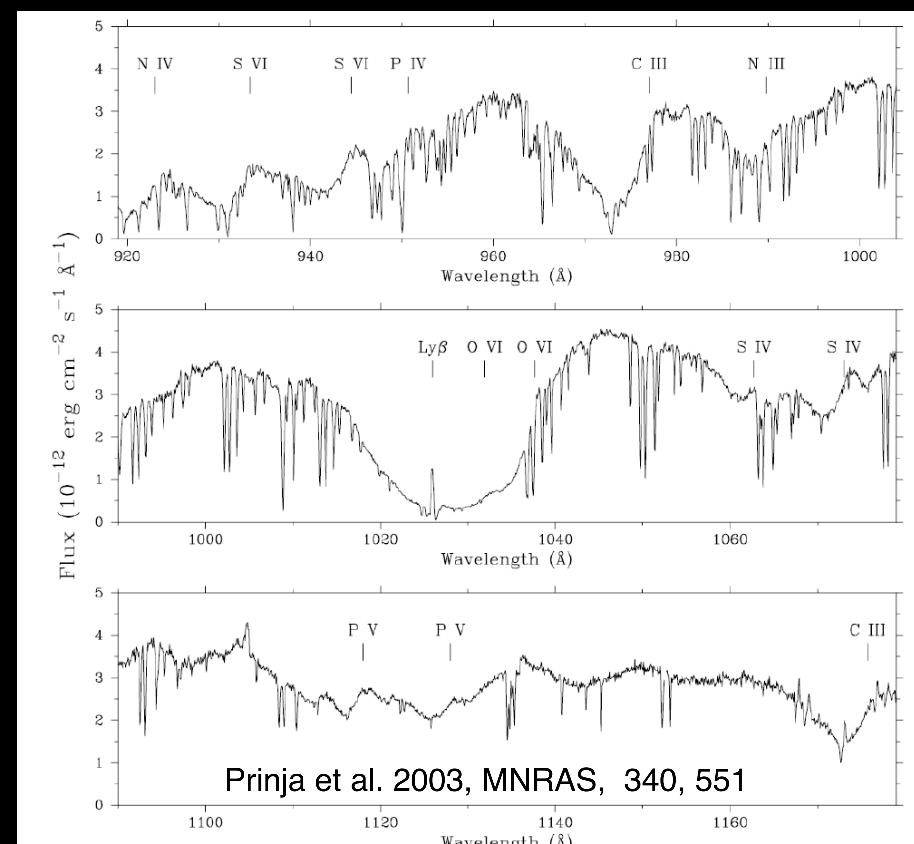
Koester, Gänsicke, Farihi
2014 A&A 566, A34

Fundamental questions :

- **What is the origin of magnetic fields in white dwarfs?**
  - Probe the possible merger origin via time-resolved spectropolarimetry
  - Does the incidence of magnetism, and the field strength evolve with cooling age?
  - Fundamental atomic physics that is beyond the capabilities of laboratories

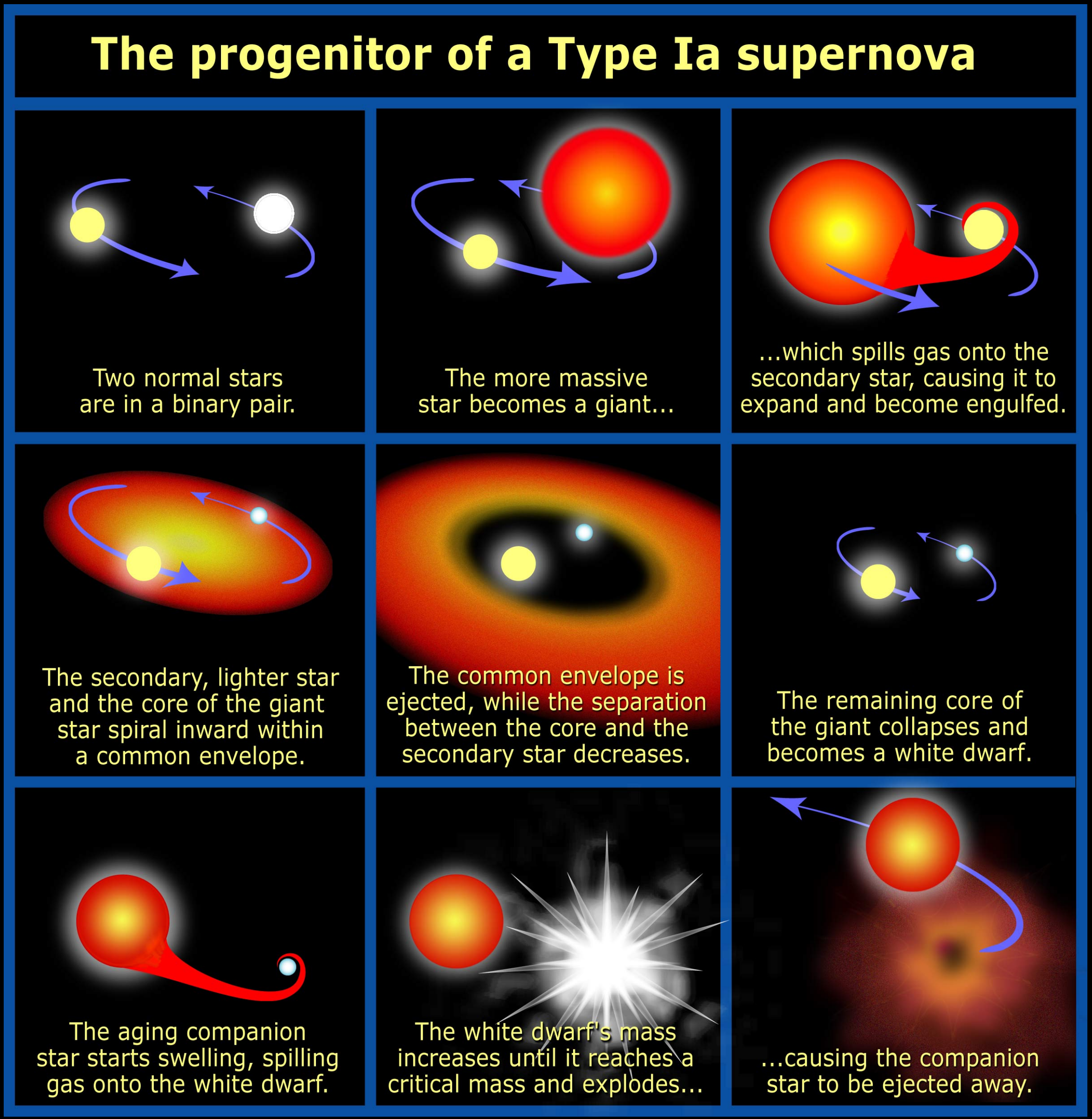
- **The physics of accretion discs**
  - Do accretion discs generate detectable magnetic fields, and can those drive angular momentum transfer?
  - Infer the dust size distribution and composition from the polarization signature of debris discs from the tidal disruption of planetesimals around white dwarfs





Fundamental questions :

- **Under what conditions to white dwarfs ignite as type Ia supernovae?**
  - Can white dwarfs accreting from main-sequence binaries grow in mass?
  - What are the properties of the population of short-period white dwarf + white dwarf binaries?



- What will be the low-frequency signal from short-period binaries for future gravitational wave missions such as e-LISA?

- How many white dwarfs undergo thermal timescale mass transfer?

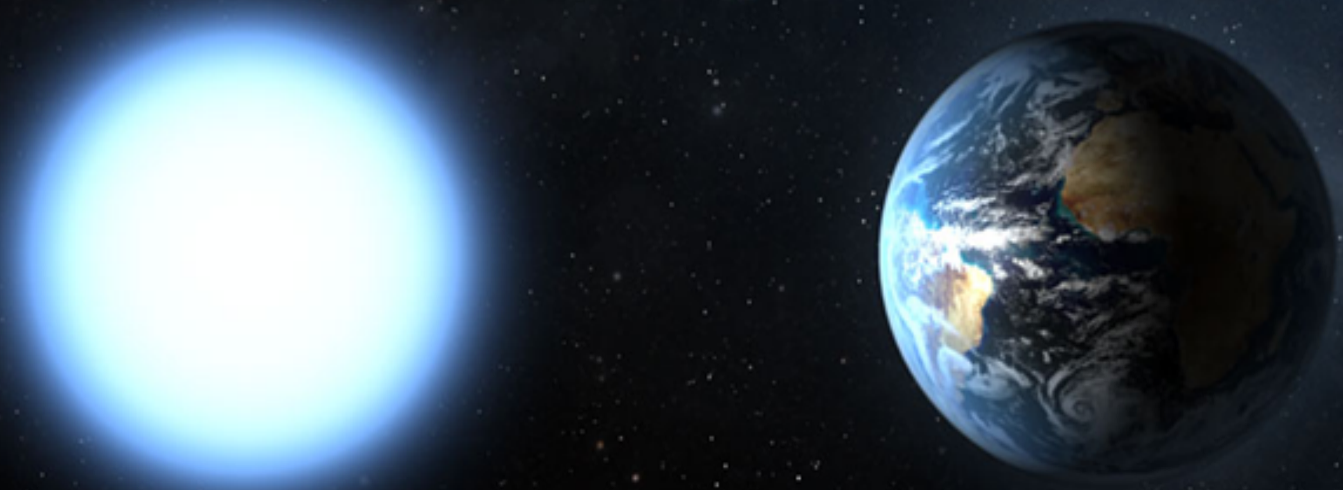
White dwarfs are small and faint

⇒ HST/COS observations are limited to a small number of white dwarfs

R ~ 10 000 km

M < 1.4 Msun

L ~ 0.001 Lsun



White remain hot (>10,000 K) for about a Gyr

⇒ rich set of metal transitions at short wavelengths

⇒ need for 9-16m aperture in the UV

Parameter	**Requirement**	**Reason for requirement**	Nice to have	Reason for nice
Shortest wavelength	98nm	Include at least 3 Lyman lines.	91nm	Cover the whole Lyman series.
Longest wavelength	180nm	Include major resonance transitions of N, O, C, Si, Al.	320nm	Overlap with ground-based spectrographs to cover the full SED.
Spectral resolution	60000	Resolve photospheric blends and ISM lines.		
Magnitude of faintest targets	UV ABmag=15.5	Several dozen good targets known.	UV Abmag=17.5	Increase the pool of possible targets to ~100.
SNR (for which exposure time and magnitude?)	SNR=50 in <1h @ 15th mag	Ability to resolve rotation and orbital periods.		
Circular (V), linear (QU), or both polarisation?	Both	V for Zeeman lines and cyclotron radiation, QU for dust scattering and more detailed field topology.		
Polarisation sensitivity	~1%	Typical polarisation signal at expected field strengths.		
Stability	RV: few 100m/s Flux: ~0.1%	Ability to detect low-mass companions and probe for flux and polarisation correlations.		

Science case for (super)Novae and Transients

On behalf of S. Shore, U. di Pisa (IT),
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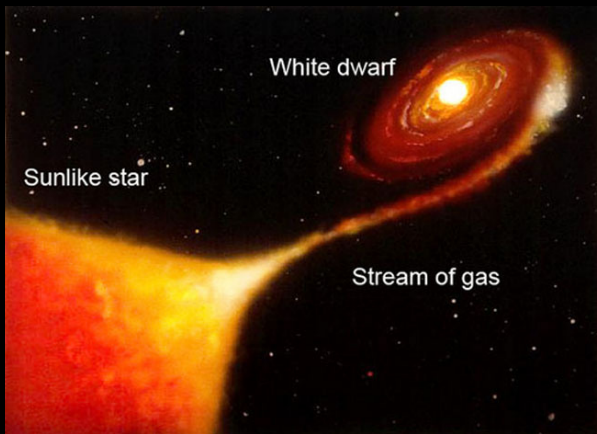
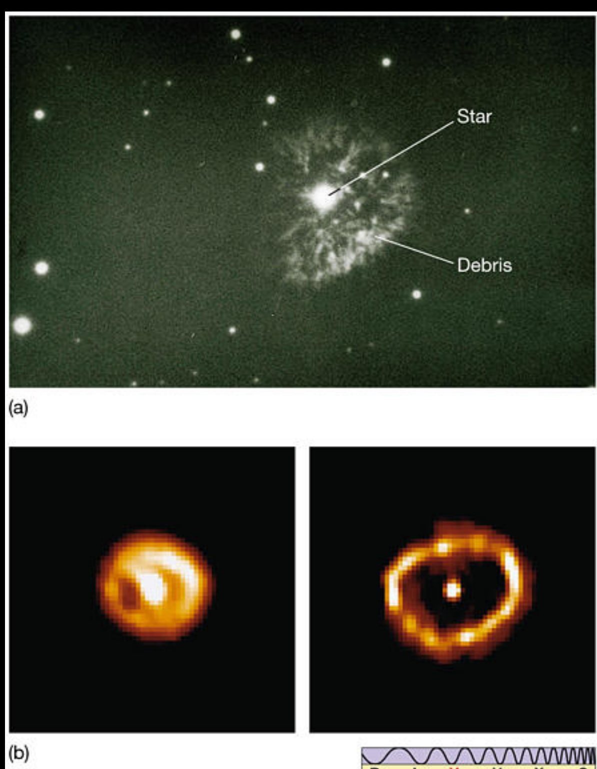
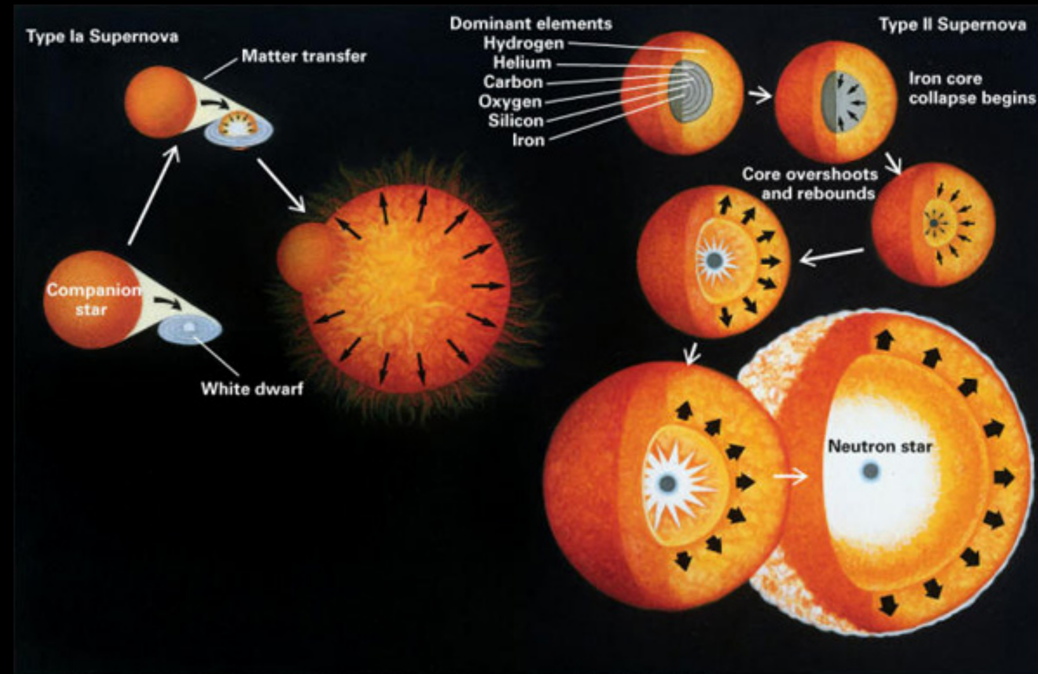
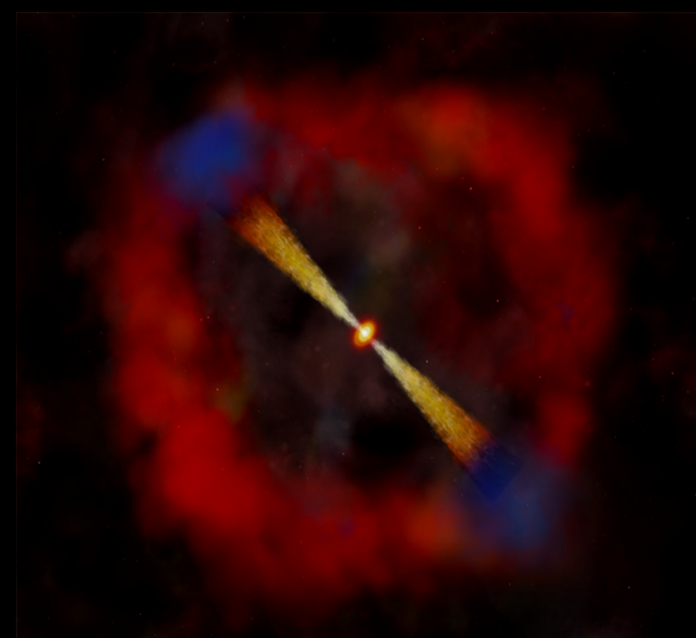
Rubina KOTAK, Queens Univ. Belfast (UK)

Various phenomena









Fundamental questions :

- **When does the accretion restarts after a nova explosion**?
  - most of the important diagnostic lines for the disk (He C N O Ne) in the UV
  - probe the thermal and density structure of the WD environment
  - probe the boundary layer of inner disk

- **How does the magnetic fields in WDs, redirect the incoming matter in quiescence**?
  - spectropolarimetry of UV lines formed in the polar regions, to separate the disk and ejecta contributions
  - magnetic fields in WDs (especially polars) redirect the incoming matter to the poles without strong dissipative heating but with a strong standing accretion shock
  - X-ray emission dominates if region is optically thin, for thicker case peak shifts into the UV

- **What are the properties of the mixing zone in the boundary layer of the mass gainer?**
  - How do they compare between different types of novae (recurrents, classical, symbiotic)
  - how does it change abundances?

- **What is the mass of the ejecta in recurrent mass transfer novae**
  - Measure masses from spectrophotometry of the ejecta

Fundamental questions :

- **What are the structural properties, especially sphericity, for novae and supernovae**
  - Earliest and late stages
  - dust formation in both type of systems

- **Abundance studies of the ejecta, especially the chemical homogeneity of the matter in both supernovae and novae**
  - abundances and ratios provide constraints on the expansion rate and type
  - interaction with the circumstellar and interstellar gas

- **nature and content of the circumstellar gas and dust at SN sites (type Ia, CCSNe)**
  - propagation of the radiative precursor from the emergent shock in CCSNe
  - Fe emission of GRB-induced fluorescent emission
  - What are the structural properties, especially sphericity, for novae and supernovae

- **Using SNe/GRBs/novae to study the absorber systems at various redshifts and ISM properties of the Galactic disk and halo**
  - probe the intracluster gas in the LG
  - probe IGM composition, attenuation
  - expand the number of transitions (better SNR and spectral resolution
  - detect novae in the Virgo cluster

Parameter	Requirement	Reason for requirement	Nice to have	Reason for nice
Shortest wavelength	900A	FUV (<1100A) essential for highest CNO ions, 1000-10000A essential for line profiles, Abundances,dynamics		
Longest wavelength	3micron			
Spectral resolution	10000-highest possible (>1E5)	circumstellar environmens,fine structure of ejecta,abundance determinations,cosmological Uses (Sne),		
Magnitude of faintest targets	V=25	extragalactic post-outburst		
SNR (for which exposure time and magnitude?)	>100 (V=25)			
Circular (V), linear (QU), or both polarisation?	(QU)	ISM,ejecta structure,light echos	V	polar variability
Polarisation sensitivity	0,01%	extinction,dust properties,ejecta structure		
Any other requirement?	time series, Temporal resolution	variability on timescales of sec to hrs (novae), Variability on hrs to days for Sne		
	target of opportunity, Response times < 0.1 day	early stages of outburst		
	high angular resolution (UV esp)	resolved studis of ejecta in late stages (Gal. And MCs)	UV,Opt	progenitor environment,light

Synthetic Requirements

Parameter	**Requirement**	Nice to have	Comments
Shortest wavelength	98 nm	90 nm	feasible below 102 nm? depends on coating...
Longest wavelength	390 nm	visible	Must overlap with red wavelength limit of the LUVOIR optical/nIR spectrograph
Spectral resolution	120000	200000	Mid-resolution also requested by some WGs, but already available through LUMOS instrument (without polarisation)
Magnitude of faintest targets	V=26		given as an indication, SNR requirement below is the important one
SNR	SNR=10 for flux 1e-17 erg/s/cm2 in the NV line in a BD within 40 pc and R=100,000 in 10,000 seconds SNR=10^5 below 156 nm integrating for 15 hours over 0.1 nm a total flux of 5x10^-17 erg cm^-2 s^-1		
Circular (V), linear (QU), or both polarisation?	Circular+linear (= QUV)		
Polarisation sensitivity	10^-6 – 10^-11		10^-6 ok, but 10^-11 likely not feasible?

Synthetic Requirements (cont.)

Parameter	Requirement	Nice to Have	Comments
Radial velocity stability	1/10th of a pixel		corresponds to 250 m/s for R=120000
Flux stability	0.001% over 30 hours		
Time resolution	1 sec in the FUV and 30 sec in the NUV		compromise agreed with US colleagues
Maximum exposure time	30 h		
Detectors	Photon-counting mode + 1-2 nm overlap between wavelength range of successive detector + accommodate high-count rate without saturation or detector damage		
Aperture size	0.03”	0.01”	
Calibration	accurate photometric calibration + usual wavelength calibration, bias, flat-fields + polarisation calibration		
Observing modes	with and without polarimetry, i.e. spectropolarimetry and pure spectroscopy modes		polarimeter will likely have to be removable
LUVOIR requirements	Multi-epoch observations of same target		
	Facility for blind offset acquisition of target		
	ToO mode with response time < 0.1 d		
	telescope as axi-symmetrical as possible, on-axis		to minimize instrumental polarisation
	the smallest possible instrumental polarisation, and a precise characterisation of this polarisation		