Our Immediate Interstellar Medium and its Impact on Stars and Planets as Revealed by High Resolution UV Spectroscopy

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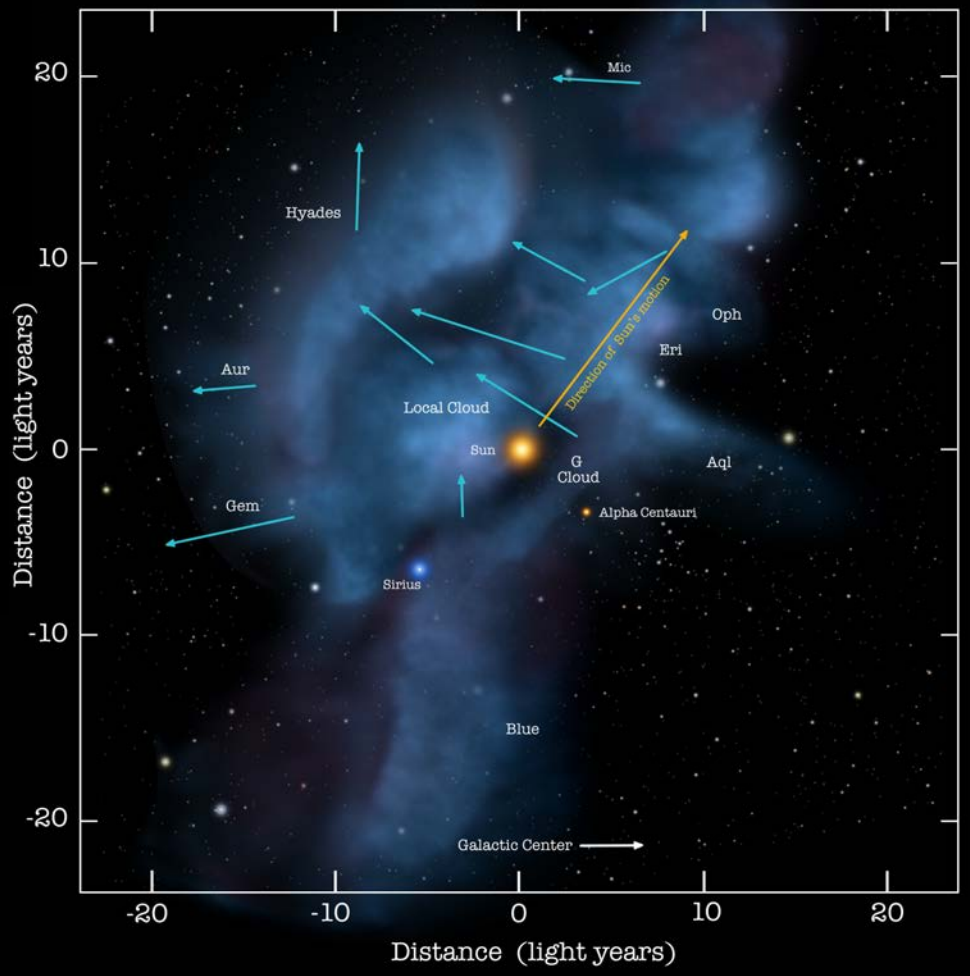
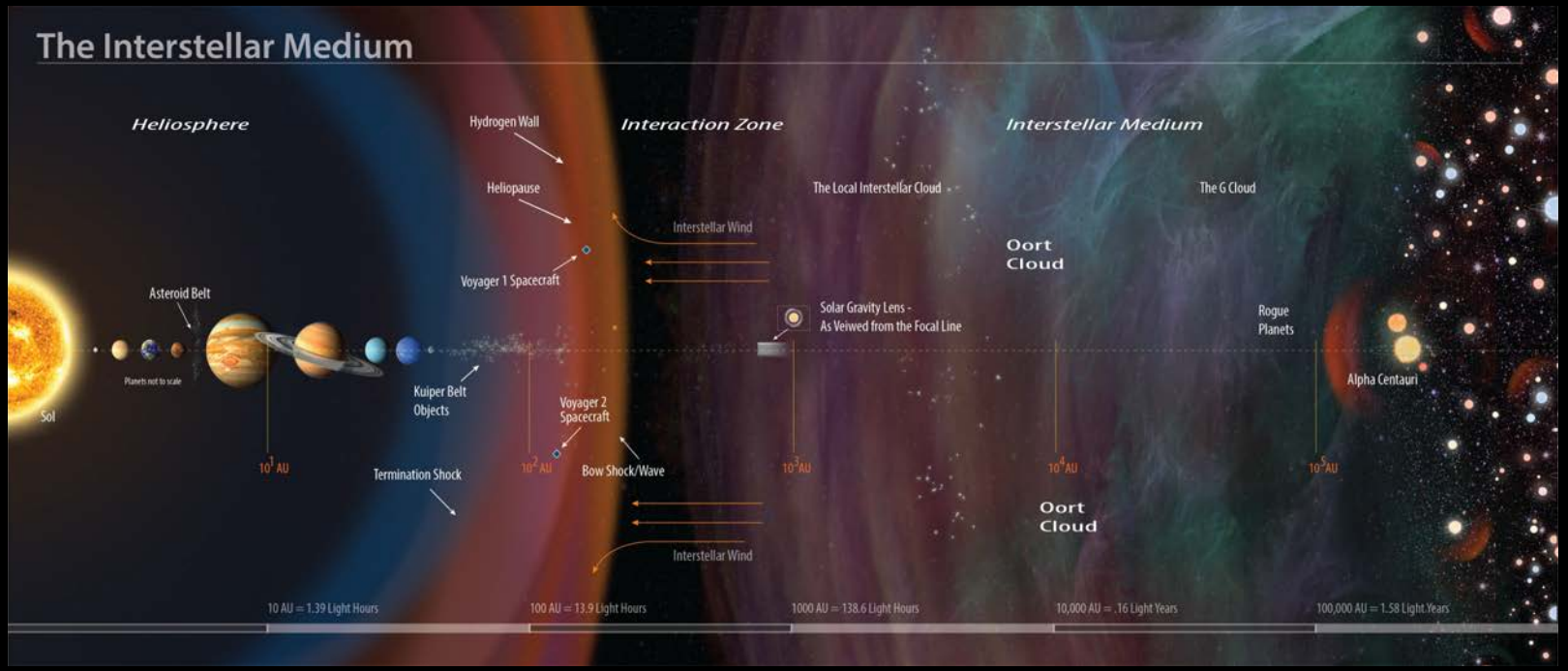


Redfield & Linsky (2008, 2015)
NASA/Goddard/Adler/U. Chicago/Wesleyan

As we work toward deep exoplanet atmospheric characterization and HWO, the local ISM is important

1. for how it will impact our observations
2. and for how it impacts planetary atmospheres



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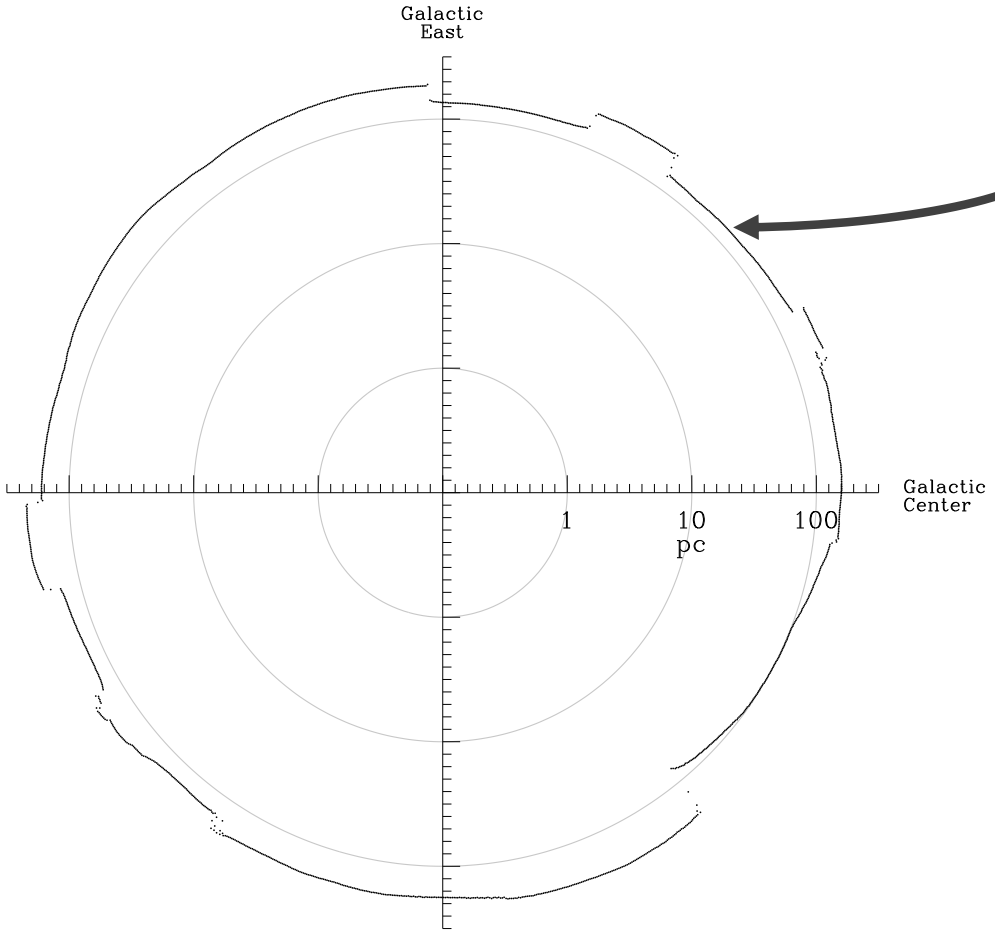
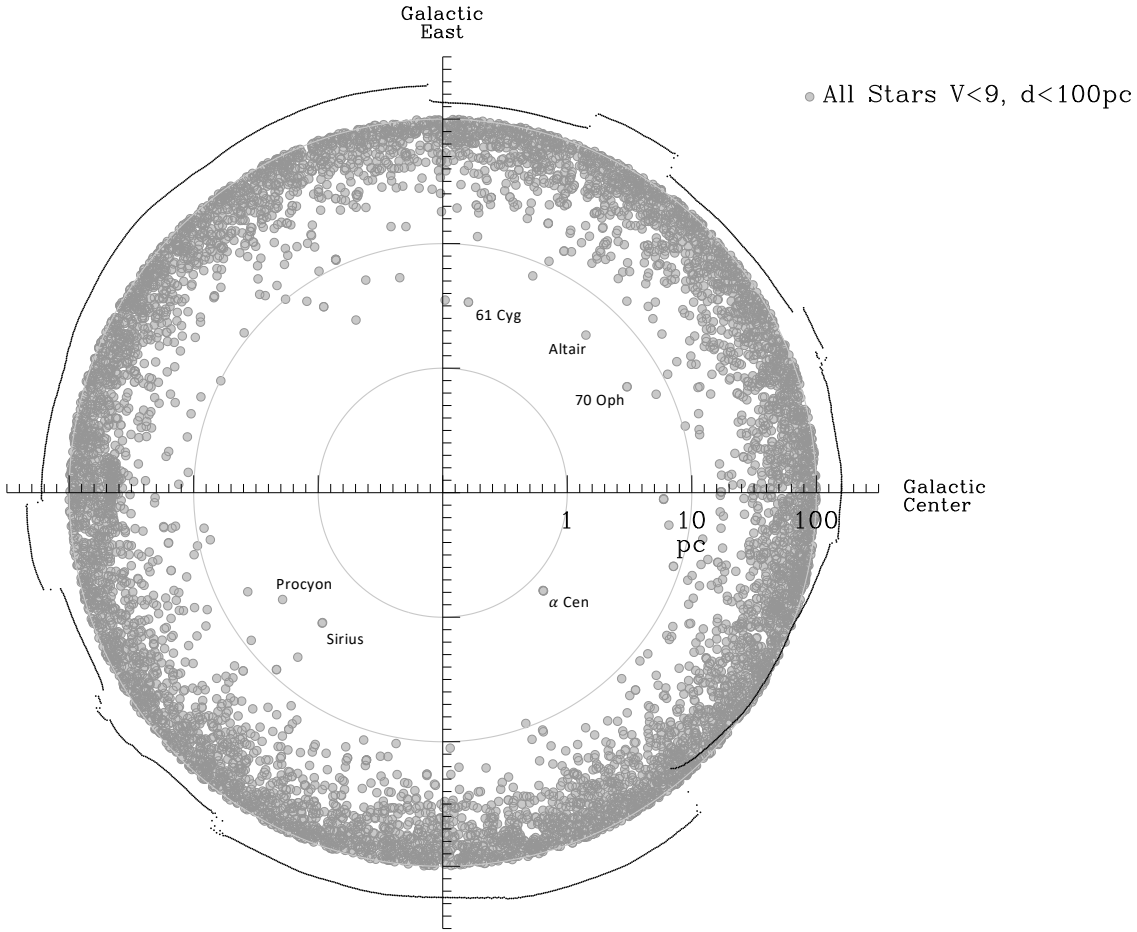
Our Cosmic Neighborhood: Local Bubble



The Local Bubble boundary (O'Neill et al. 2024)

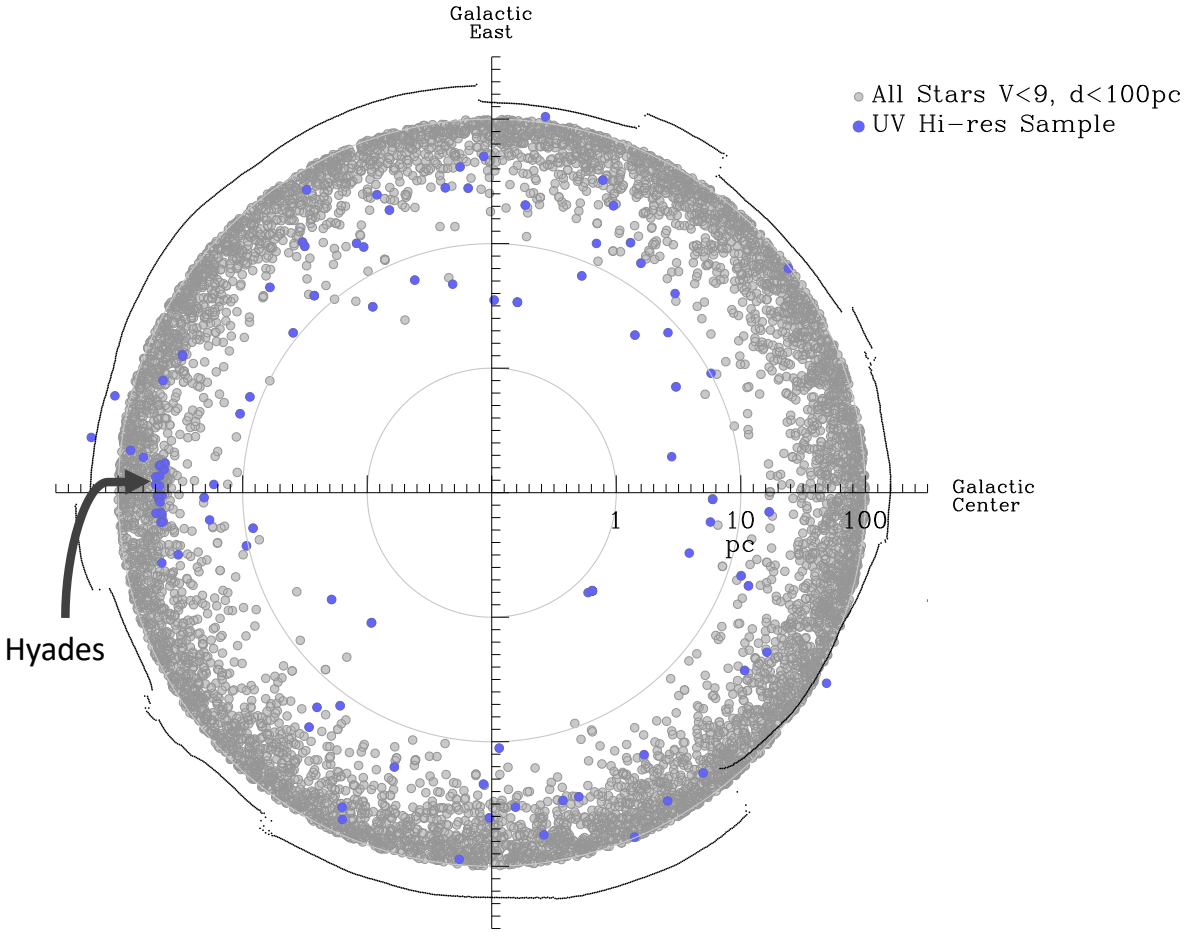
The Sun is approximately in the center of a cavity vacated by recent SN over the last 12 Myr. Dense star-forming regions exist just outside the Local Bubble. Column densities within the Local Bubble are modest: log N(HI) 17-18.5 cm^{-3}.

Our Cosmic Neighborhood: Stellar Neighbors



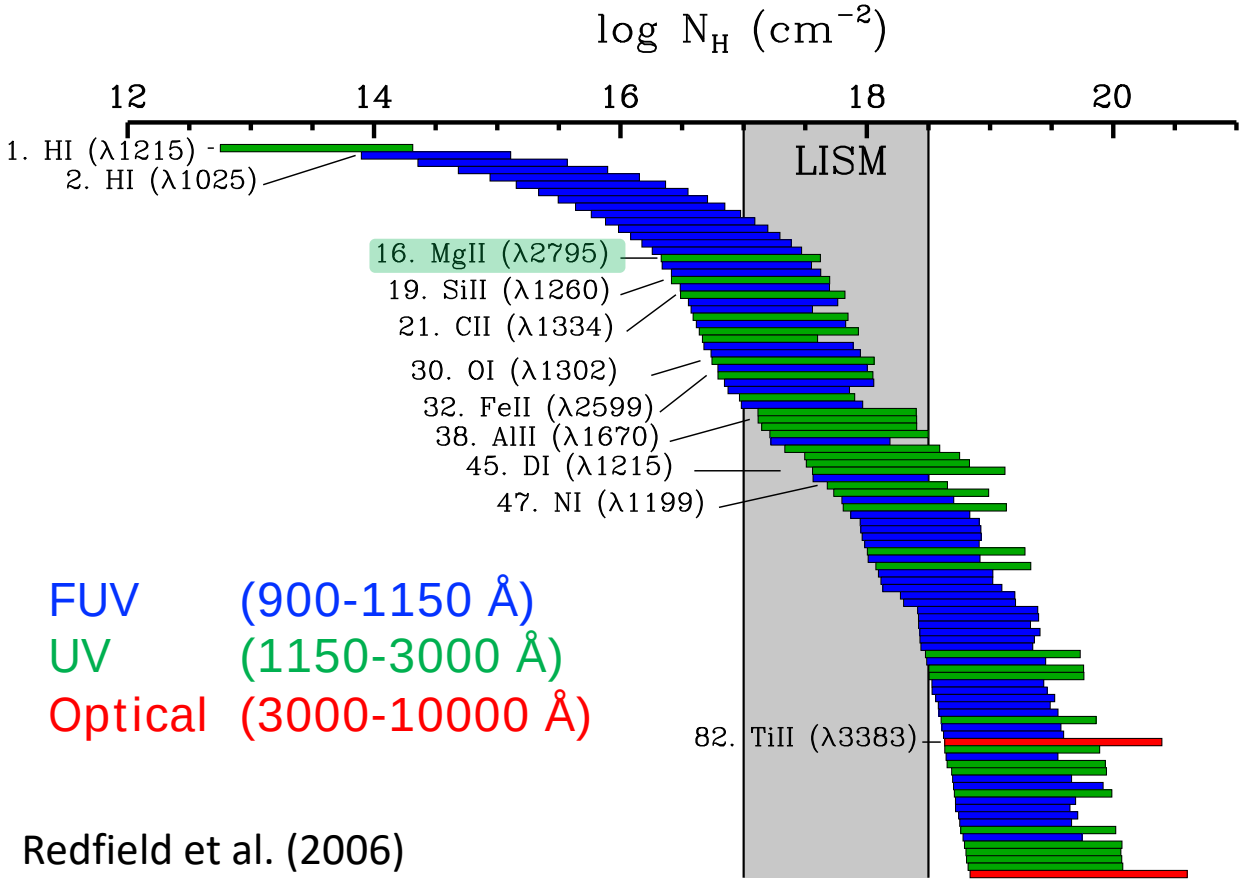
About 350,000 stars lie within 100 pc (complete to M8; *Gaia*, Smart et al. 2021). No O stars and very few B stars. The F-M and white dwarfs make excellent background sources for UV absorption line spectroscopy.

Our Cosmic Neighborhood: UV Hi-res Sample



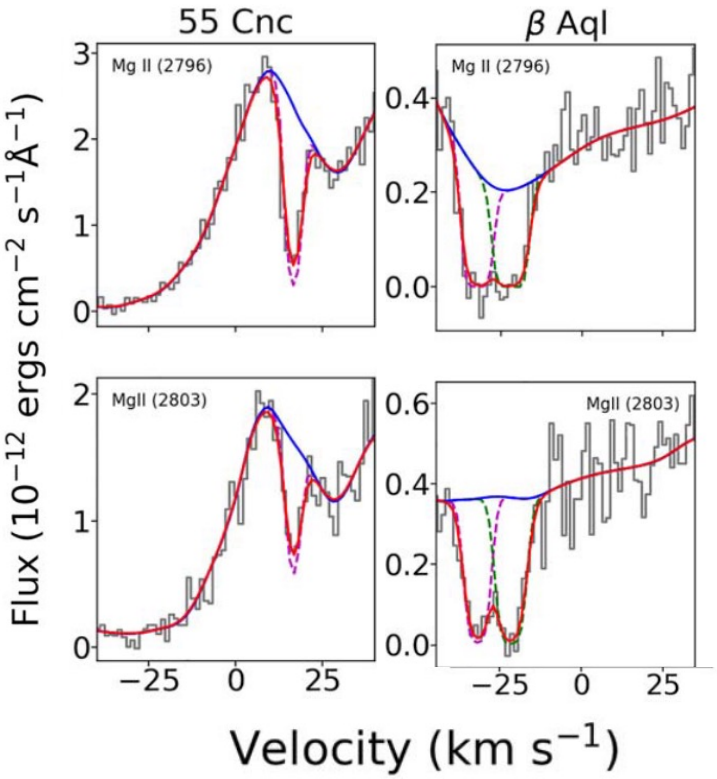
200+ nearby stars have been observed with high resolution UV spectrographs on *HST.* This sample provides a new view of the LISM and has revealed a rich and complex suite of clouds among the nearest stars.

Fewer than 100 transitions are sensitive to the LISM and they are all in the UV or FUV



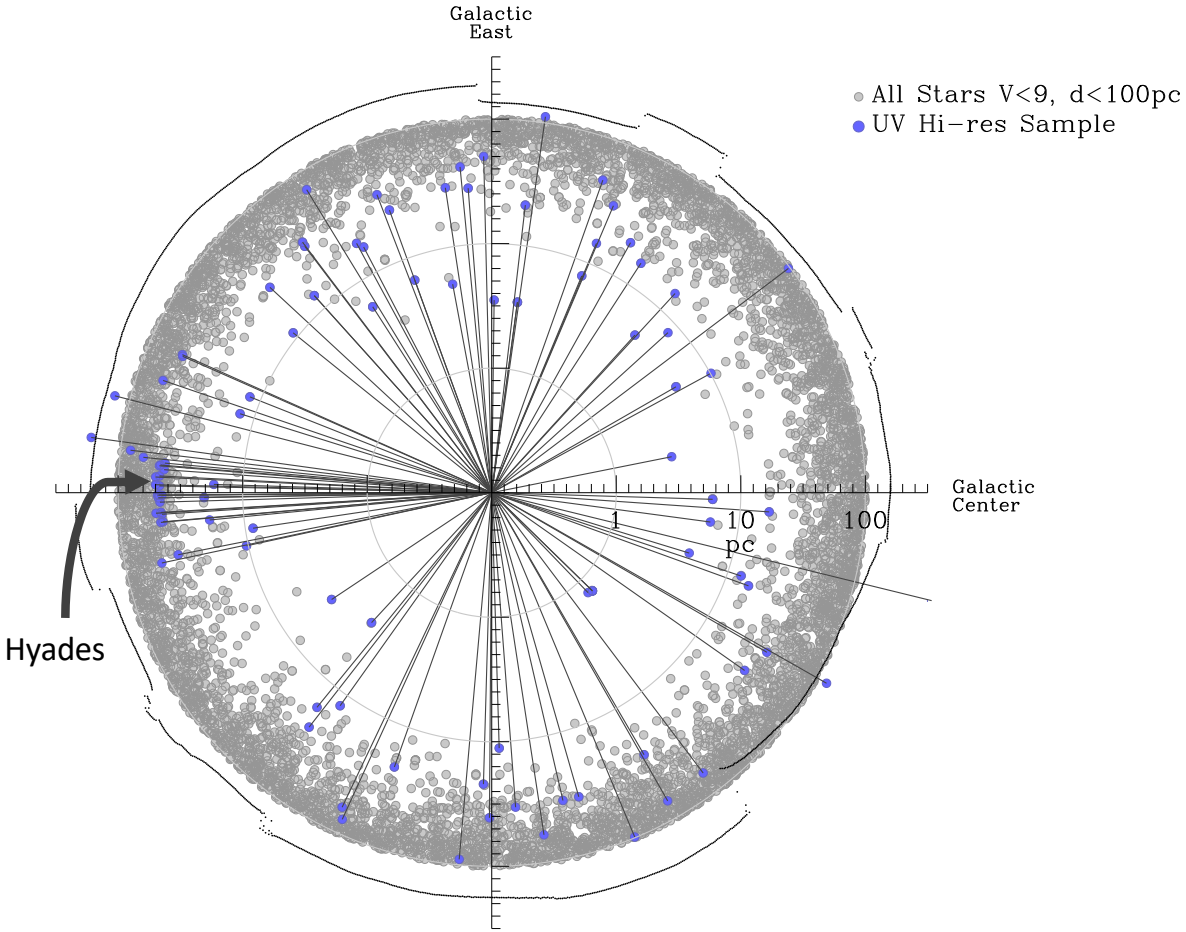
FUV (900-1150 Å)
UV (1150-3000 Å)
Optical (3000-10000 Å)

Redfield et al. (2006)



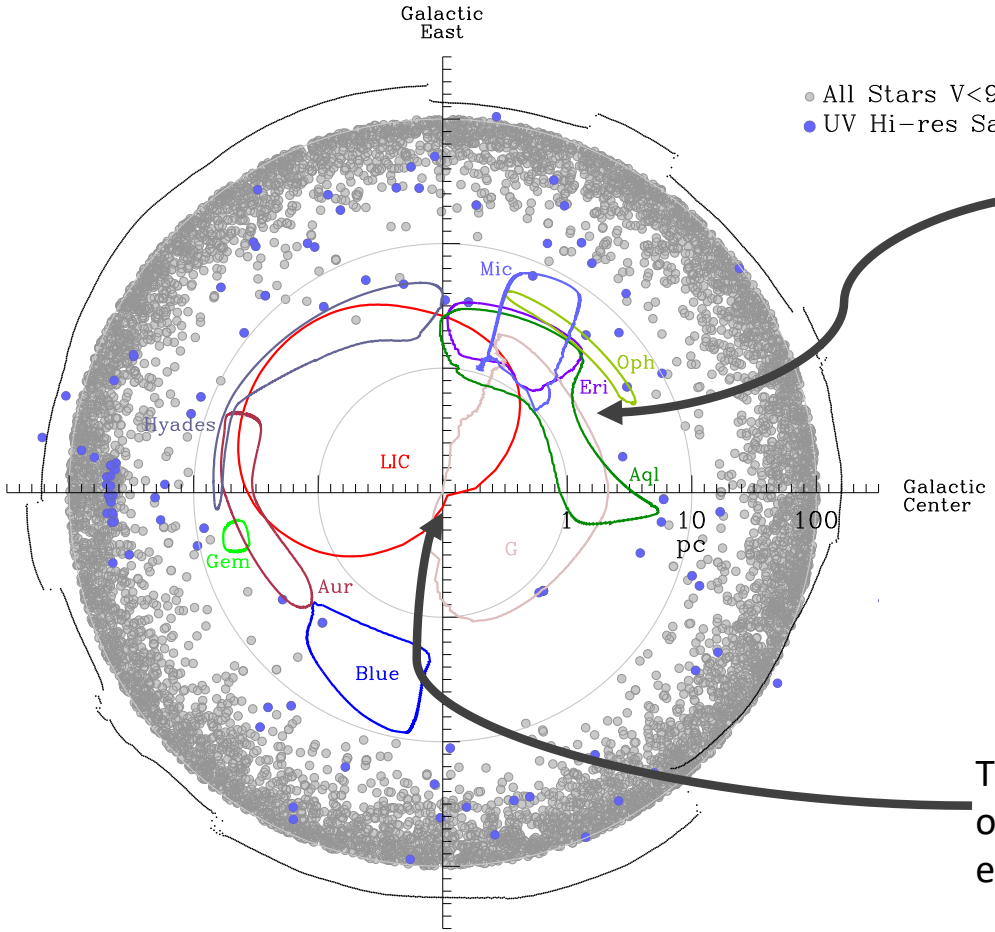
Nisak et al. (2025)

Our Cosmic Neighborhood: UV Hi-res Sample



50+ papers on the analysis of LISM UV high-resolution absorption spectra, including several SNAP surveys (e.g., Nisak et al. 2025).

Our Cosmic Neighborhood: LISM



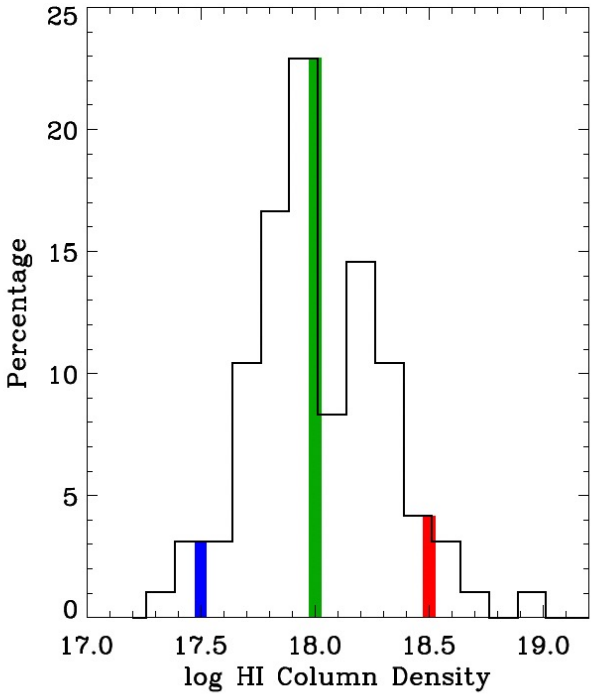
15 dynamically distinct LISM clouds within 15 pc (Redfield & Linsky (2008; 2015).

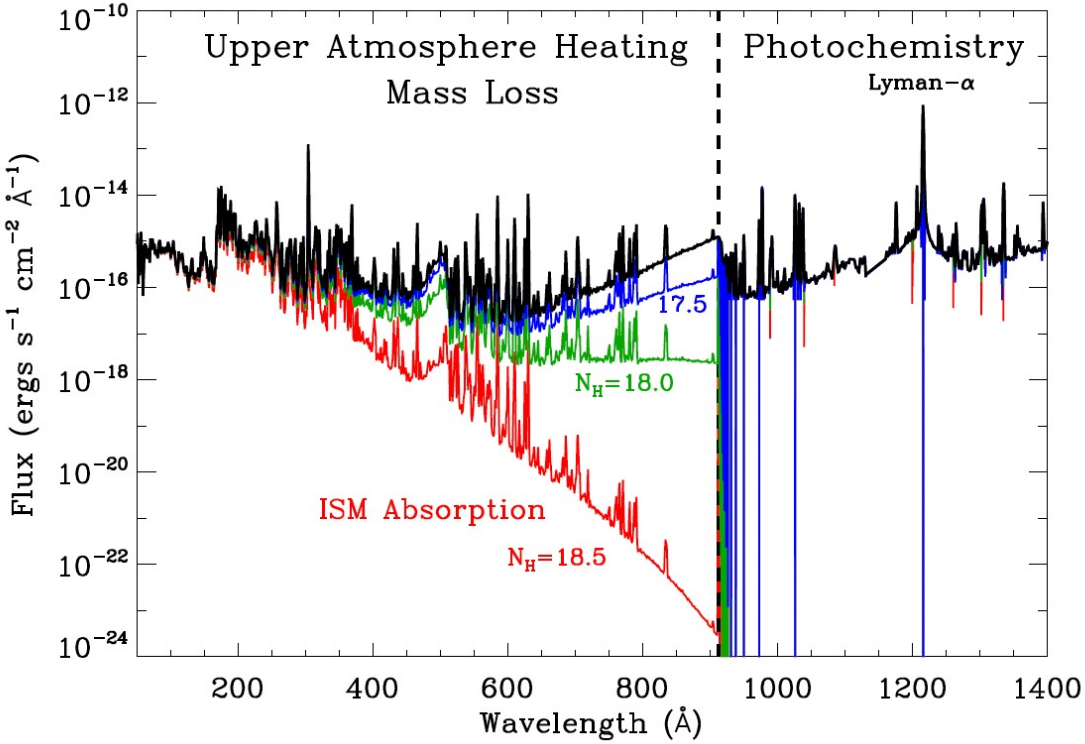
Challenges:

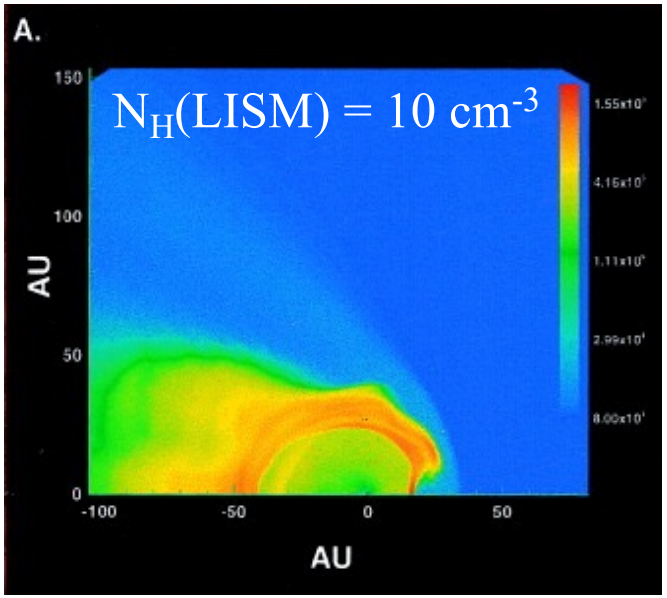
1. Right in the middle of it
2. Relatively low column density
3. Limited background star sample
4. Require UV high-res spectra

The Sun is right at the boundary of the LIC and G clouds (Swaczyna et al. 2022)

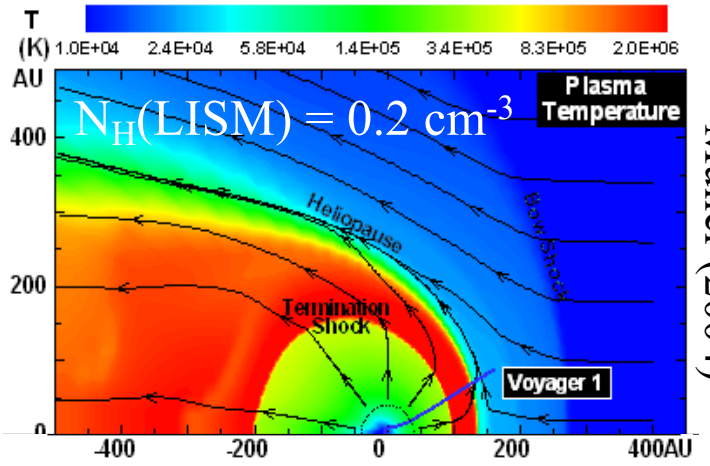
While modest, the range of LISM column densities lead to a wide range of EUV absorption







Zank & Frisch (1999)



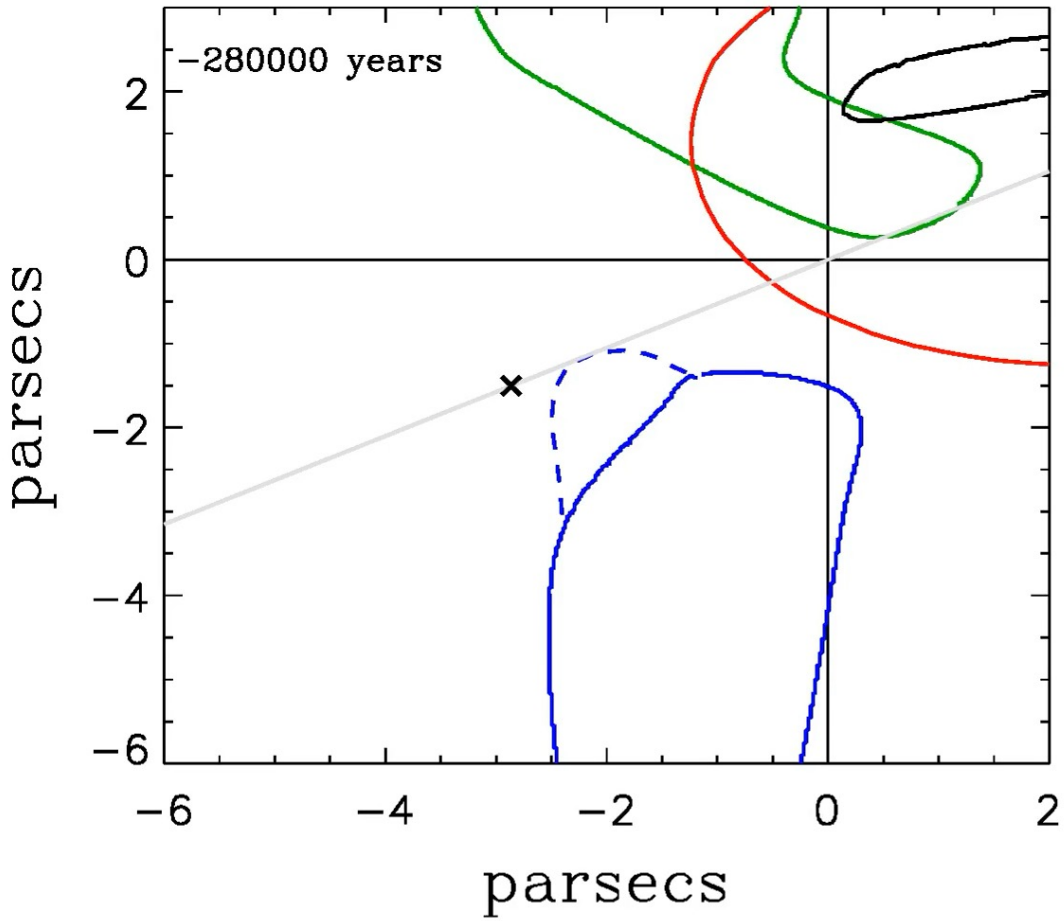
Müller (2004)

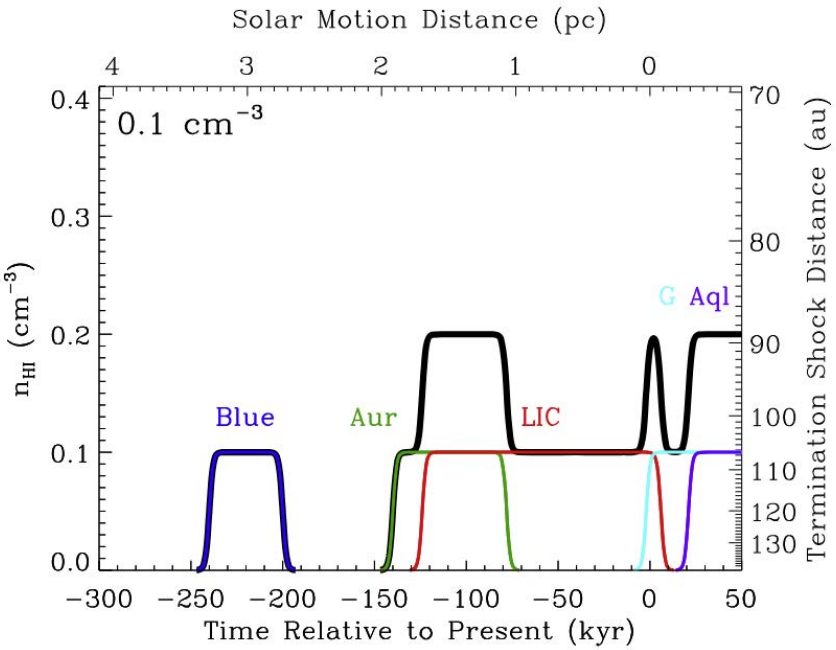
The size of the heliosphere dictates the cosmic ray flux on planets, which in turn may influence:

1. Outer solar system surface weathering
2. Atmospheric energy budget
3. Atmospheric ionization and cloud formation
4. Surface and subsurface DNA mutation rates

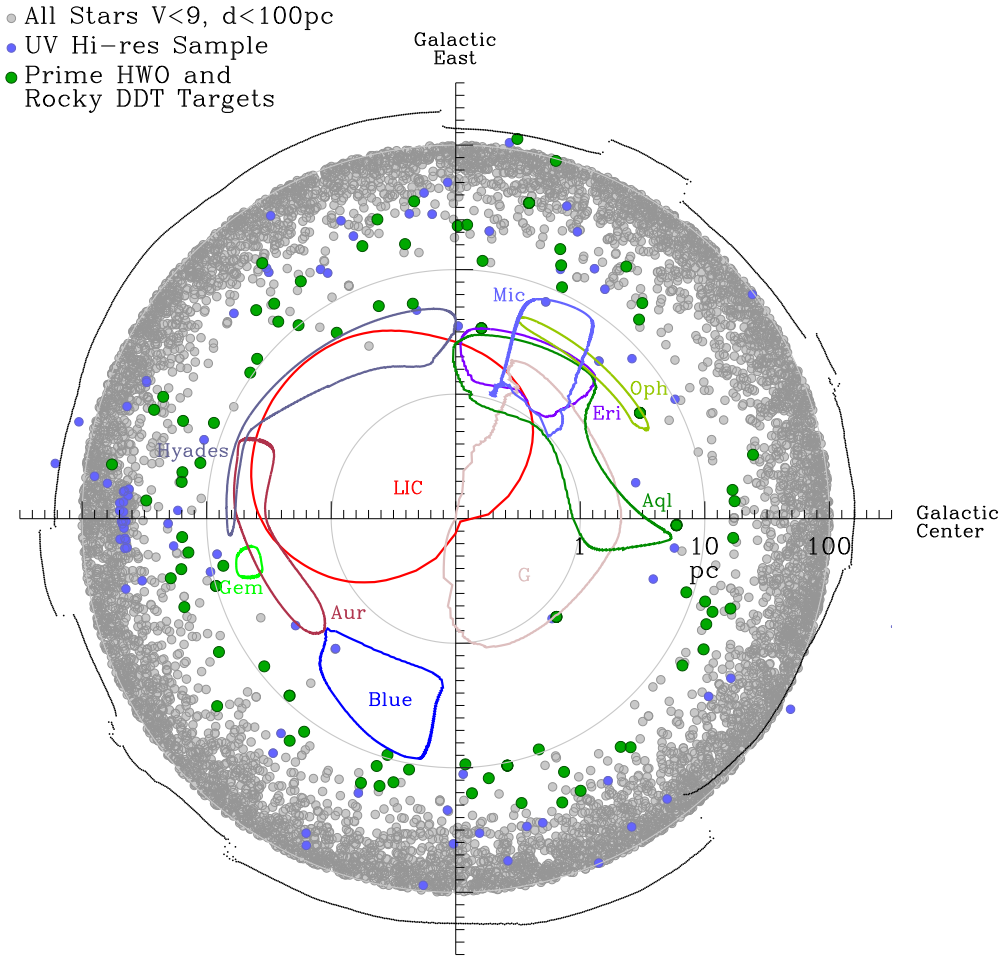
Such investigations have a long history (see review in Redfield (2006)! Shapley (1921), read Fred Hoyle's *The Black Cloud* (1957), Fahr (1968), Begelman & Rees (1976), Frisch (1998), Pavlov et al. (2005), Wyman & Redfield (2014), Opher et al. (2024), Vannier et al. (2025)

The Sun is moving in and out of LISM clouds over the last 25 kyr.



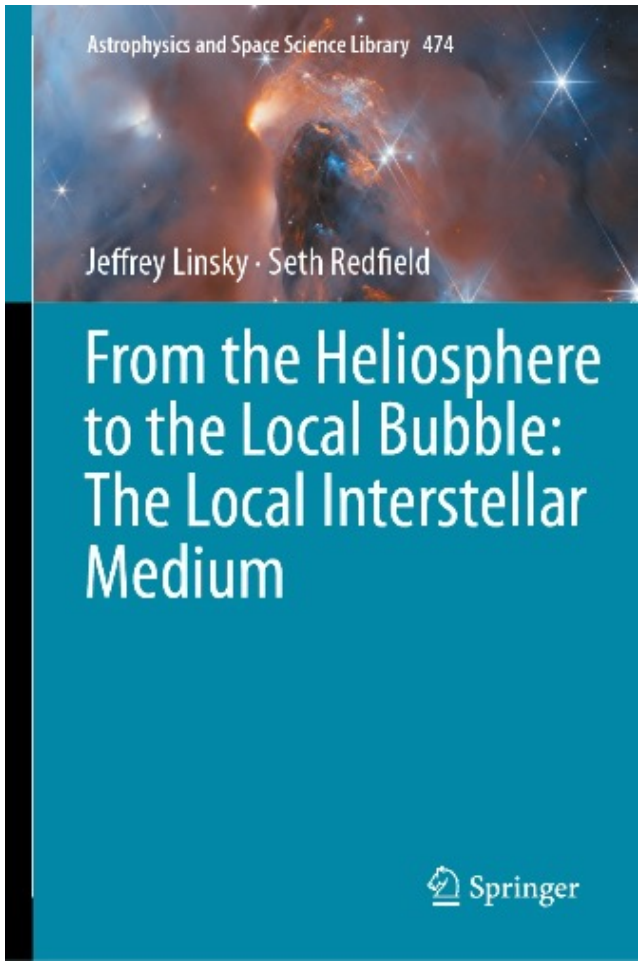


Vannier, Redfield, et al. (2025)



Takeaways

1. The LISM is a rich and complex environment that surrounds the Sun and the nearest stars.
2. These observations require high-res UV spectroscopy and the LISM results in dramatic EUV absorption even toward the nearest stars.
3. The LISM controls the size/shape of the heliosphere/astrosphere and which changes the interplanetary medium of planets.
4. The LISM shares the same volume as the planets that we will be evaluating for habitability (e.g., Rocky Worlds DDT: Redfield et al. 2024; and ExEP Star List for HWO: Mamejeck & Stapelfeldt 2023).
5. Jeff Linsky and I recently published a book on the LISM (Springer). Check out Chapter 2.



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