The Smith Stream: Investigating the Makeup of the Smith Cloud

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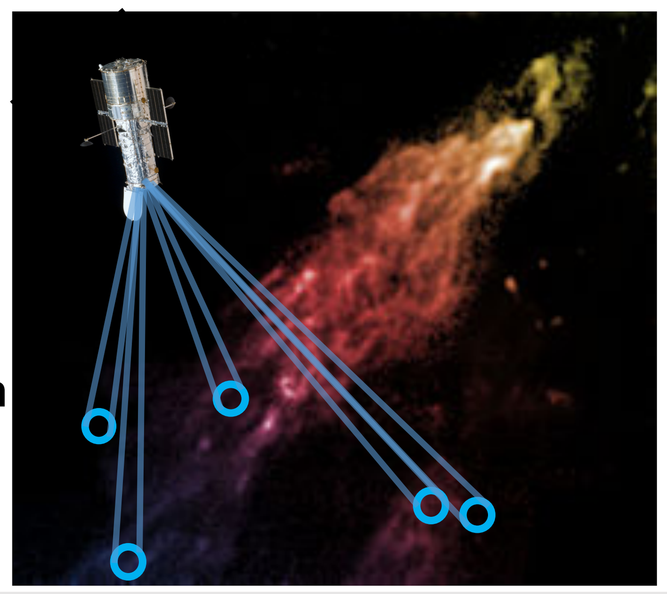
1. Background

The Smith Cloud is a high-velocity gas cloud that is beginning to phase through our Milky Way galaxy. It is travelling at an astonishing speed of 220 km/s relative to our Galaxy. Previous studies have shown that the Smith Cloud may have a high fraction of heavy elements or "metals," which could imply it came from our Galaxy.

We use the Hubble Space Telescope, Green Bank Telescope, and simulations to determine the properties of the gas within the Smith Cloud. This helps to determine the makeup of the Smith Cloud: the heavy element concentration and dust fraction.



2. Telescope Observations

- **Measure amount of hydrogen**
  - **Use Green Bank Telescope to detect hydrogen emission in radio**
- **Measure amount of heavy elements**
  - **Hubble Space Telescope to detect heavy elements in absorption in UV**

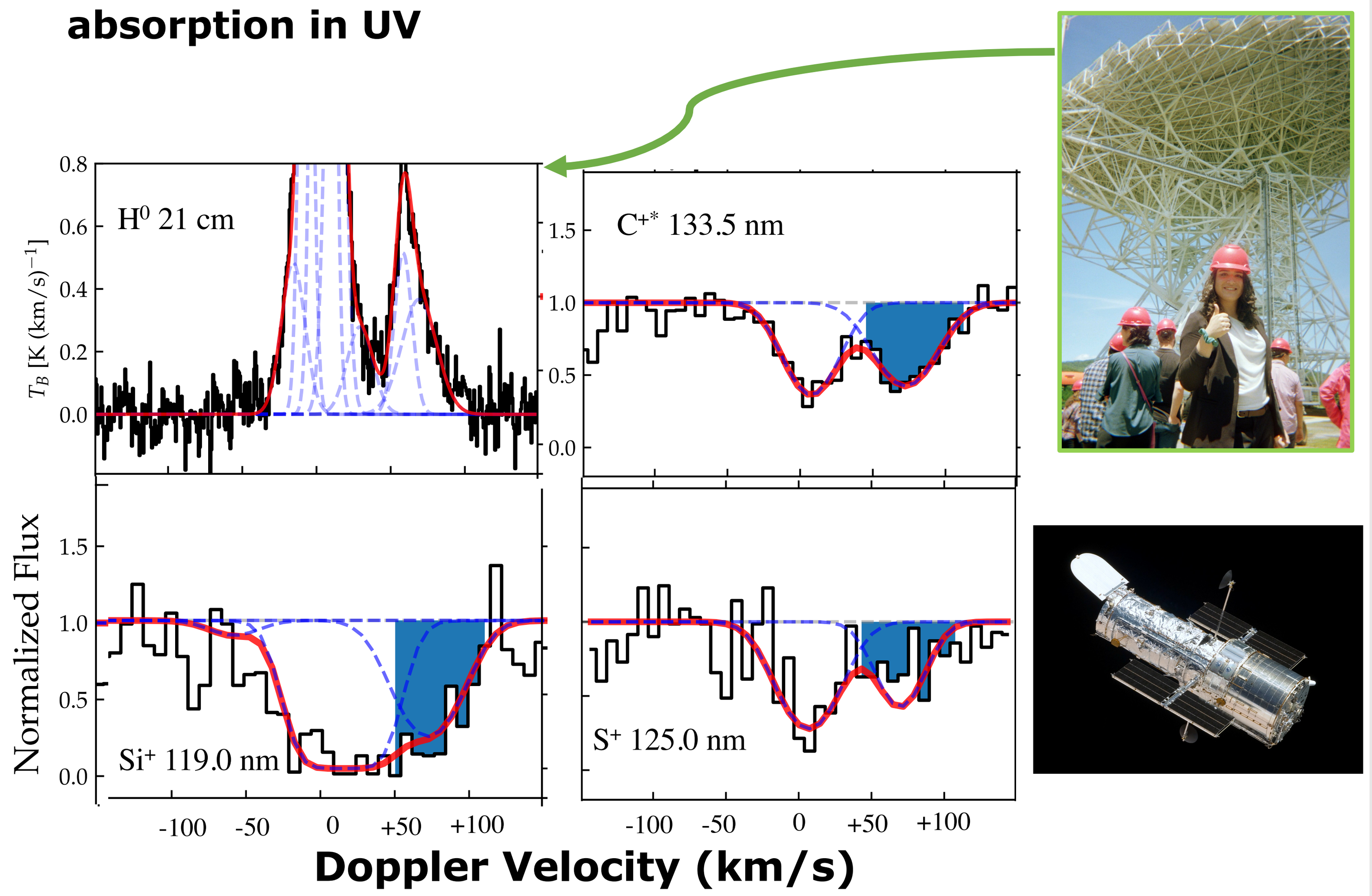


Figure 1: Green Bank Telescope emission spectrum of neutral hydrogen and absorption spectra of various ions with the Hubble Space Telescope.

3. *Cloudy* Modeling

- ***Cloudy* photoionization, Ferland *et al* (2017)**
- **Compare hydrogen density (n_H) to measured density ratio of Si^{2+}/Si^{+} => ionization conditions.**
- **Compare calculated (constant/n_H) to ionization correction.**
- **Determine heavy element concentration from ionization correction**
- **Use calculated heavy element concentration to find the dust depletion**

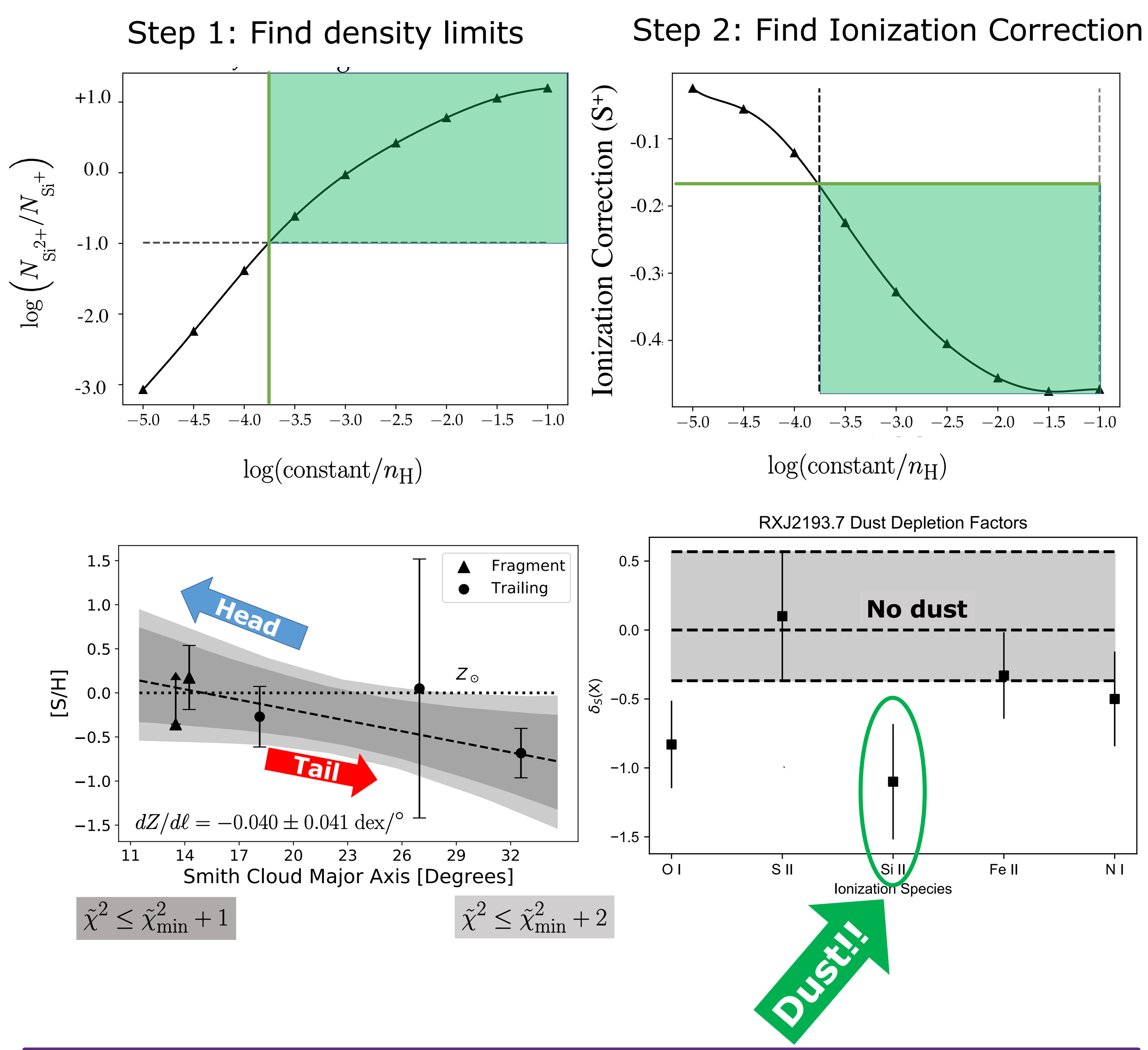


Figure 2: (top left panel) The derivation of the hydrogen number density (n_H) limit based on the ionization ratio Si^{2+}/Si^{+}; (top right panel) the derivation of the ionization correction for the S^{+} ion based on previously derived hydrogen number density. The green shaded areas in the top panels indicate allowed values; (bottom left panel) the ratio of sulfur per hydrogen normalized to the Sun vs the Smith Cloud's major axis (the direction of travel); (bottom right panel) the logarithm of the relative ratio of various elements to sulfur plotted against ions.

4. Results

- **Maximum heavy element concentration of [S/H] = +0.18±0.36 dex**
  - **Higher than our Sun!**
- **Dust depletions factors of:**
  - **[Fe/S] = -0.30 ± 0.33**
  - **[Si/S] = -1.10±0.40**
- **Metallicity gradient: -0.040 ± 0.041dex/°**

6. Conclusions

- **Galactic origin**
  - **High "metallicity" imprint from MW**
  - **High dust fraction**
- **Mixing with the Galactic halo**
  - **Metallicity gradient**

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Using the Hubble Space Telescope, we are investigating a gargantuan gas cloud on a collision course with our Galaxy. Scientists have debated for decades where this gas cloud came from. Some think it came from inside our Galaxy while others say it came from outside our Galaxy. Now we know! With a high concentration of heavy elements and the presence of solid dust particles, we can trace the origins of this mysterious cloud back to our Milky Way Galaxy!

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Acknowledgments

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