What is the CGM?

Tumlinson et al. (2017)
Cold Extraplanar Gas

NGC 891
Atomic Gas
HI – 21 cm

Oosterloo et al. (2007)
Warm ionized Gas

- M82
- Combined Hα (T~10^4 K), IR, optical

Cold Neutral Gas  Warm Ionized Gas
• Also M82
• CO (1-0) contours + HI (colorscale)
• Extraplanar!
- Also M82
- Chandra X-ray \((T > 10^6)\)
But, is the CGM warm-hot?
The Simulated CGM

Tumlinson et al. (2017)
Absorption Line Findings

- Large OVI columns to ~150 kpc
- Diffuse / occupies bulk of halo
  - NOT shock front or boundary layer
- >10% of entire galactic feedback energy goes into support
- Contains more mass than stars!
- Caveats: Assumptions on filling factor; no morphological info
- We do not have ‘eyes’ on the dominant matter component of galaxies
We need to map warm-hot (coronal) gas...

So, why haven’t we?

"While the hot gas observed with Copernicus is very similar to the extended corona suggested nearly twenty years ago, the origin and spatial distribution of the observed coronal gas is not at all certain.” – Lyman Spitzer, 1976
• Strongest line – OVI @ \( \lambda \lambda \) 1032, 1038 Å, rest-frame
  • Need to go to space!
• Surface brightness < 1 x 10^{-18} erg s^{-1} cm^{-2} arcsec^{-2} (near z=0)
• Filaments \( \rightarrow \) luck?

UV optics/detectors are historically inefficient at these wavelengths...

It’s hard to get to space...

Otte et al. (2003) + Corlies (private comm) + Haeun Chung
High-reflectance UV Coatings
M. Quijada, NASA GSFC

MCP Detectors
Ossy Siegmund
Sensor Sciences, LLC

Falcon 9
SmallSat Rideshare

Until Now!
Nearly half of the Aspera team is early-career, with strong support from experienced scientists and engineers.
These *were* the only existing OVI emission detections in the nearby universe!
And Then Haeun Chung Came Along...

Revisiting FUSE O VI Emission in Galaxy Halos

Haeun Chung, Carlos J. Vargas, and Erika Hamden
University of Arizona, Steward Observatory, 933 N. Cherry Ave., Tucson, AZ 85721, USA; haunchung@arizona.edu
Received 2021 March 5; revised 2021 May 21; accepted 2021 May 23; published 2021 July 20

- Archival FUSE data
- 4 new detections!
  - First detection in NGC 891 – a high extinction target
- Improved estimate of expected OVI SBR via analogous measurements!
Implications for future OVI Detections

- Aspera is specifically designed to detect and map OVI
- Aspera’s sensitivity lead is due to low contribution from background noise and large ‘grasp’ (étendue)
- Big science can be done in a small platform!
Selection Criteria:

- $i > 78^\circ$
- $R_{\text{opt}}$ sampleable
- $cz$ sampleable
- Hubble type later than Sa (star forming)
- No starburst or AGN
  - Simplifies interpretation
- No close companions
  - Avoids confusion
- Visible in LEO
- Extinction < 1 mag @ OVI
  - NGC 891 extinction = 0.98 mag, and it was detected with FUSE
  - 10 of 18 targets have extinction < 0.35 mag
- Lots of existing ancillary data at other wavelengths for many of these!

<table>
<thead>
<tr>
<th>Name</th>
<th>RA (J2000)</th>
<th>Dec (J2000)</th>
<th>Priority Group</th>
<th>Optical Diameter ('')</th>
<th>D (Mpc)</th>
<th>cz (km/s)</th>
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<td>NGC 4631</td>
<td>12h42'8&quot;</td>
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ASPERA
REVEALING THE DIFFUSE UNIVERSE

Target Selection

Priority 1 Targets

NGC 253
NGC 891
NGC 1353
NGC 3003
NGC 4631
NGC 5746
Aspera Payload

- EFFICIENT AND REDUNDANT, WITH HERITAGE

- 4x Identical Rowland Circle-like optics
  - Design inspired by FUSE
- 103-104 nm FUV spectrograph
  - Spec R: \( \sim 2000 \), Spatial R: 45 arcsec
  - FoV: 60 arcmin x 30 arcsec (per ch.)
- Sensitivity: \( 4.3 \times 10^{-19} \) erg/s/cm\(^2\)/arcsec\(^2\)
- TRL \( \geq 6 \) Technologies
  - Mirror, Grating, Coating, & Detector
- Payload mass, power: 24 kg, 27 W
Micro-Channel Plate Detector

- **FUV SENSITIVE TRL 9 DETECTOR**

- Supplied by Sensor Sciences, LLC (Dr. Oswald Siegmund)
- Cross delay line (XLD) Microchannel plate
- FUV sensitive CsI photocathode (QE>40%)
- Spatial resolution < 35 micron
- Previously flown multiple times, high TRL technology
Spacecraft Bus

- Provided by the University of Toronto Institute for Aerospace Studies (UTIAS) Space Flight Laboratory (SFL)
- ESPA-class DEFIANT platform
  - Spacecraft mass: $\sim 35 \text{ kg}$
  - Payload mass: $\sim 24 \text{ kg}$
  - Payload volume: $36 \text{ cm} \times 36 \text{ cm} \times 56 \text{ cm}$
• Mission duration: 9-month (1 month checkout + 8 month science ops)
• Orbit: Sun-Synchronous Dawn-Dusk (Altitude: 600-900 km LEO)
The Path Ahead

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<tr>
<th>CY 2021</th>
<th>CY 2022</th>
<th>CY 2023</th>
<th>CY 2024</th>
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<td>BRIDGE</td>
<td>PHASE B:</td>
<td>PHASE C&amp;D: Implementation</td>
<td>PHASE E</td>
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<td>5 mo.</td>
<td>4 mo.</td>
<td>Formulation / 13 mo.</td>
<td>28 months</td>
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<td>SC PAYLOAD ATLO 10/3</td>
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We are here
Dominant baryonic component of galaxies is still unmapped.

**Aspera**: UV SmallSat mission for imaging warm-hot coronal gas in nearby galaxy halos
- *Selected for funding in 2020 NASA Astrophysics Pioneers AO*
- Via O VI (1032 Å) emission spectroscopy with step-and-stare concept observation
- Inspired by FUSE, four identical 6.2 cm x 3.7 cm telescopes in a single payload
- High-throughput, wide-field, and shot-noise limited system enables detection and mapping of faint diffuse gas

Projected launch ~mid-2025 for 9-month mission