The Structure of the Milky Way's Hot Gas Halo

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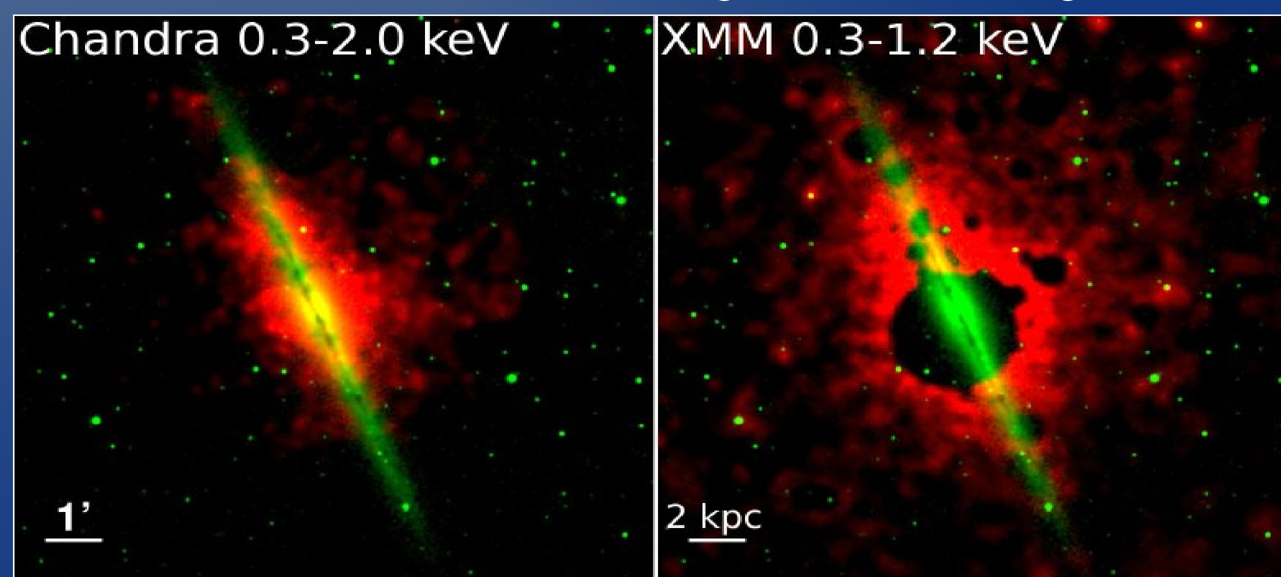
NGC 891 - Hodges-Kluck & Bregman 2012



Gas Properties

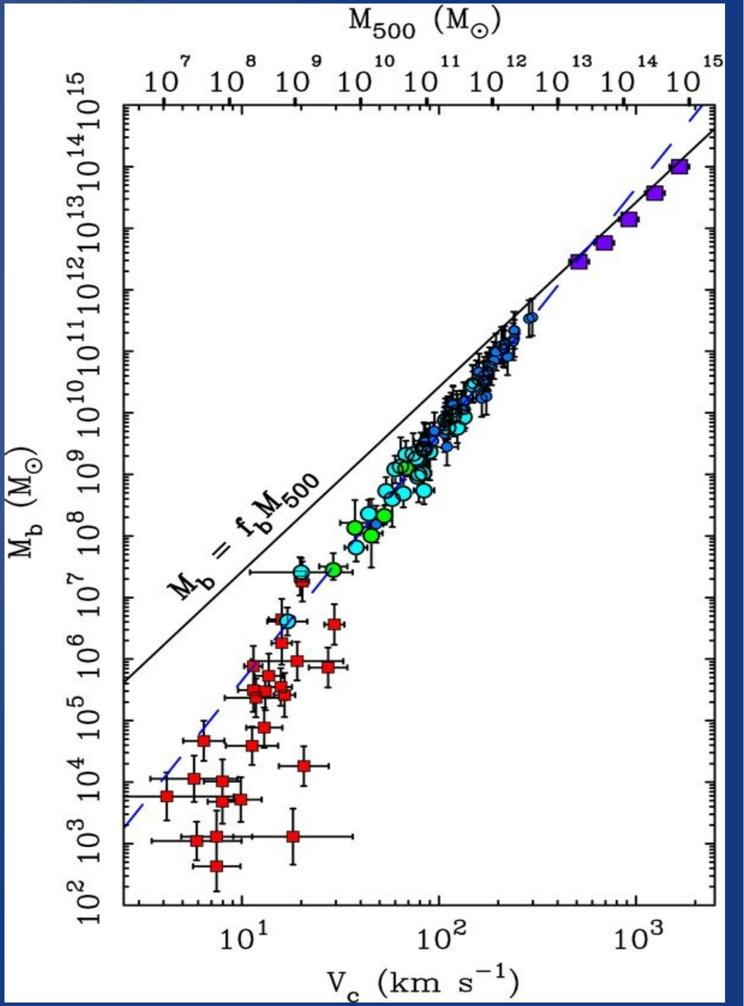
- $T \sim 10^6$ K, $n \sim 10^{-5}$-10^{-3} cm^{-3}, volume-filling on large scales

- Gas at this temperature has multiple potential sources
  - gas is shock heated at T_{vir} as it falls into a galaxy's dark matter potential well
  - supernovae winds create galactic fountain scenarios with galactic outflows/inflows

- Potentially a large source of baryons in the Milky Way

- Average spiral missing ~90% of its baryons

- Our goal is to improve the current density profile constraints on the halo gas and determine if the gas can account for some or all of the Milky Way's missing baryons

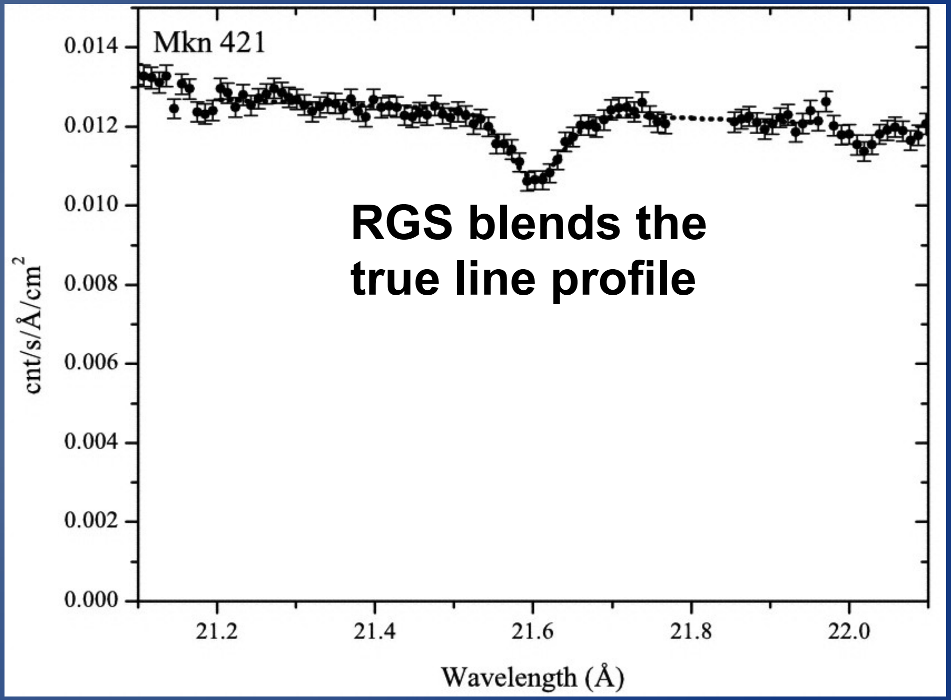


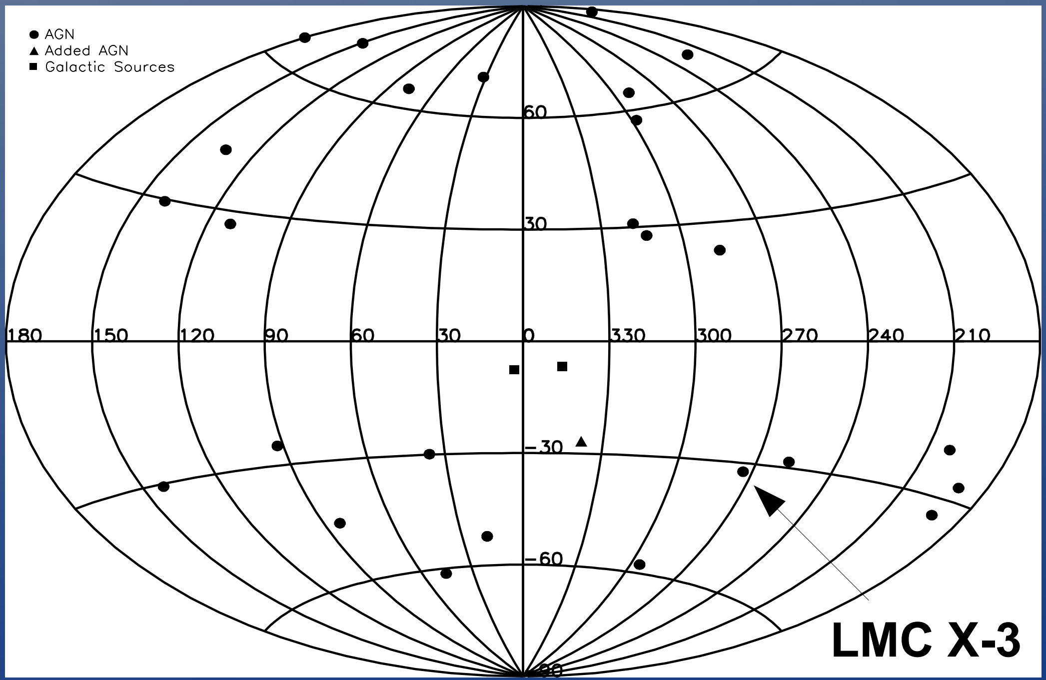
McGaugh et al. 2012

Our Sample

- We measured OVII equivalent widths at 21.603 Å and converted these to OVII column densities (all from RGS on *XMM-Newton*)

- 26 AGNs, 2 Galactic sources, and 1 LMC source





- Results limited by number of sources near the Galactic center

Assumptions

- Initially assume the lines are optically thin – eventually look at saturation effects since the lines are likely mildly saturated
  - Assume gas is turbulent at the sound speed of hydrogen (~150 km s^{-1} for $T \sim 10^6$ K) – typical correction factors of ~2

- Solar oxygen abundance / metallicity when converting from OVII to electron columns (initially)

- Gas is distributed as a <u>spherical</u> β profile

$$n(r) = n_o \left[1 + \left(\frac{r}{r_c} \right)^2 \right]^{-\frac{3}{2}\beta}$$

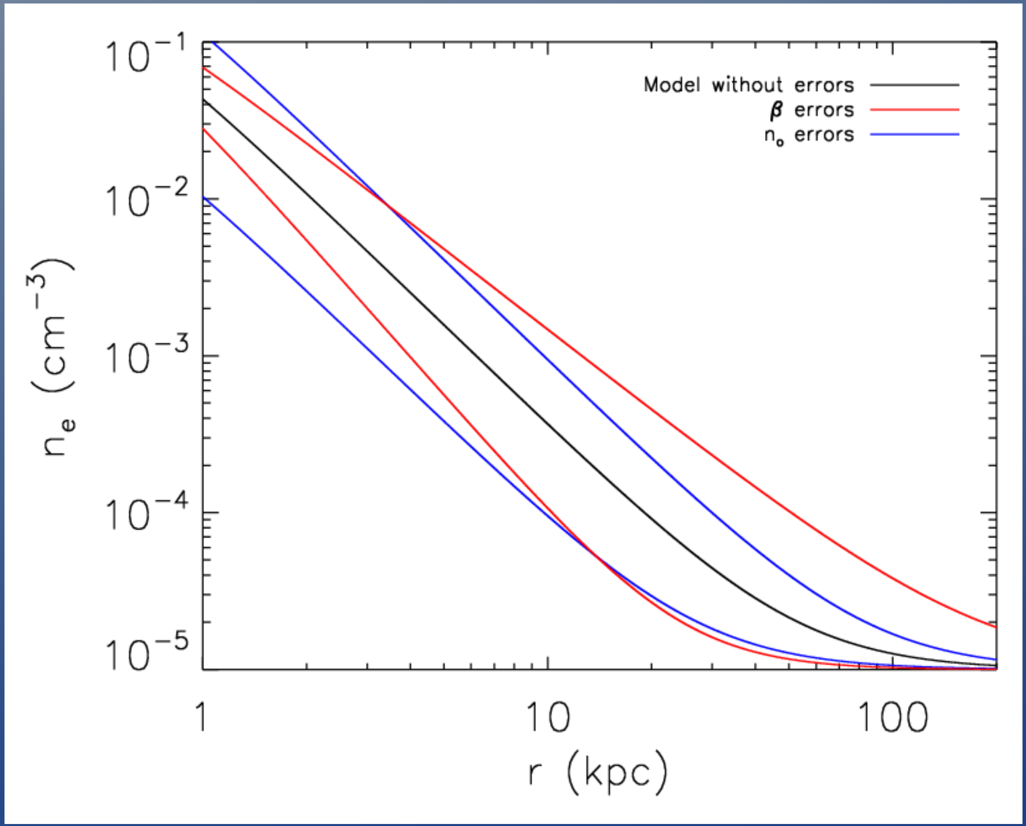
  - β is most important for constraining mass

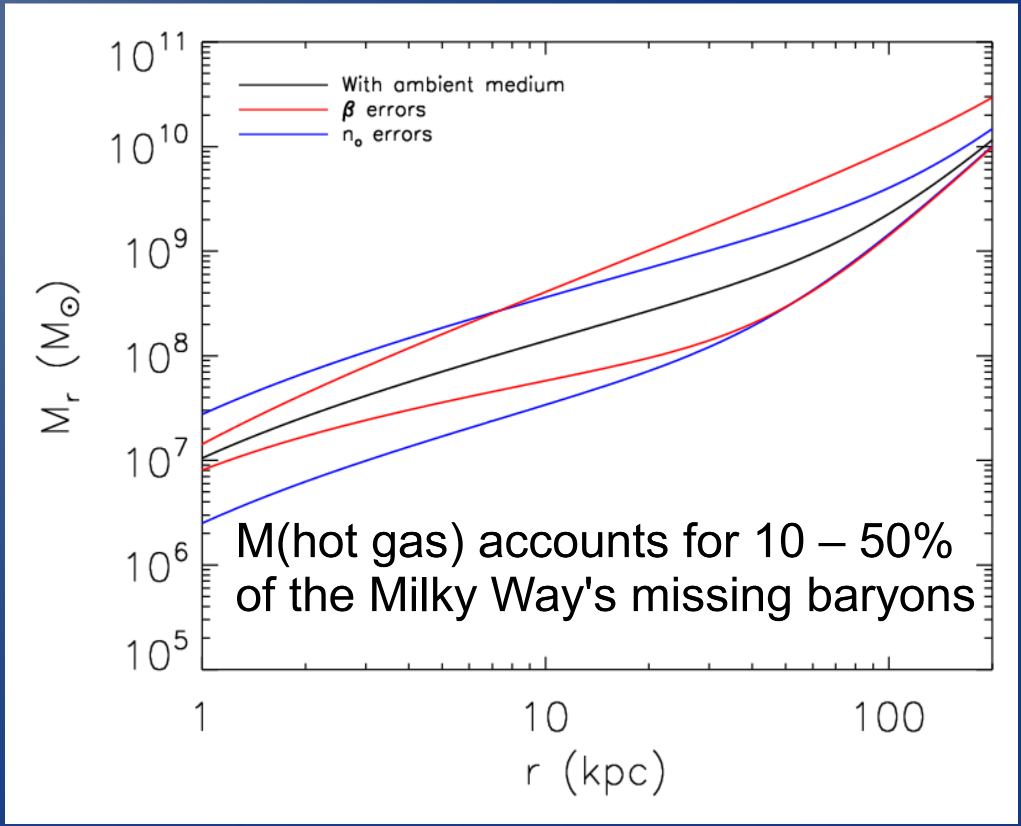
  - Typical values are $r_c < 1$ kpc and $\beta \approx 0.5$

Results

χ^2(dof) = 26.0 (26)
$n_o = 0.46^{+0.74}_{-0.35}$ cm^{-3}
$r_c = 0.35^{+0.29}_{-0.27}$ kpc
$\beta = 0.71^{+0.13}_{-0.14}$

For $f_b = 0.17$, $M_{missing} = 3.6 \times 10^{11}\ M_\odot$
Assuming $Z_{gas} = 0.3\ Z_\odot$...
$M(18\ \text{kpc}) = 7.5 \times 10^8\ M_\odot$
$M(200\ \text{kpc}) = 3.8 \times 10^{10}\ M_\odot$





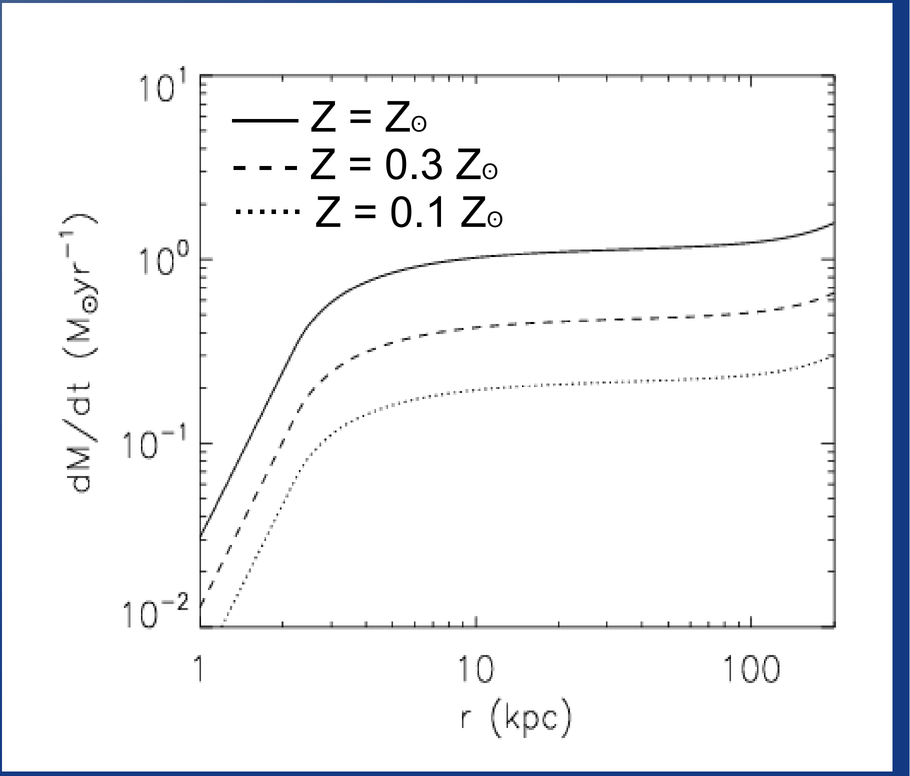
Metallicity

- Still have not directly measured halo gas metallicity

- A number of our results imply $Z \approx 0.3\ Z_\odot$
  - Pulsar dispersion measure towards LMC results in $\langle n_e \rangle \leq 5 \times 10^{-4}\ cm^{-3}$ (Anderson & Bregman 2010)
  - For our halo model, this implies $Z \geq 0.2\ Z_\odot$
  - Only certain for this line of sight and for gas out to ≈55 kpc

  - $\dot{M}(0.3\ Z_\odot) = 0.2 – 0.7\ M_\odot\ yr^{-1}$ (< Milky Way's SFR)
  - $L_X(0.3\ Z_\odot) = 2 \times 10^{39}$ ergs s^{-1} (≈ observed 0.5-2.0 keV luminosity)

- This metallicity is consistent with both cosmological simulations (Cen & Ostriker 2006) and (some) HVCs (Fox et al. 2005)



Summary

- We have constrained the density profile of the Milky Way's hot gas halo assuming it is distributed as a β profile
  - $n_o = 0.46\ cm^{-3}$, $r_c = 0.35$ kpc, $\beta = 0.71$

- For a metallicity of 0.3 $Z_\odot$, the mass of the halo is [0.2, 3.8] x $10^{10}\ M_\odot$ for r = [50, 200] kpc
  - This implies the halo gas accounts for 10 – 50% of the Milky Way's missing baryons

- We are able to place a lower limit on the halo gas metallicity of $Z \geq 0.2\ Z_\odot$ based on the pulsar dispersion measure towards the LMC

- Our model is consistent with several Milky Way observables, particularly if we assume a metallicity of 0.3 $Z_\odot$

- Also see poster 120.08 - “Missing Baryons in Galaxies” (Bregman et al.)