TRANSITION TEMPERATURE GAS IN THE GALACTIC HALO

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WARM GAS T ~ 5000 K
TRANSITION TEMP. GAS T ~ 10^5-10^6 K
HOT GAS T > 10^6 K

THE FUSE O VI SURVEY
O VI IN THE GALACTIC THICK DISK
DISTRIBUTION AND KINEMATICS OF O VI
RELATIONSHIPS WITH OTHER ISM TRACERS
THE ORIGINS OF O VI
Primary Collaborators

FUSE O VI SURVEY
Wakker et al. 2003 ApJS, 146, 1

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High Ionization ISM / IGM Species

Collisional Ionization Equilibrium, Solar Abundances

- XMM/Chandra: O VII, O VIII
- FUSE: O VI, S VI
- HST: N V, C IV, Si IV

ISM COOLING CURVE
PEAKS NEAR
T ~10^5 to 3x10^5 K

A MAJOR COOLANT IS EMISSION FROM O VI

FUSE Spectra with Low and High Velocity O VI Absorption

O VI
1031.926 Å (usually clean)
1037.617 Å (often blended)

A SAMPLE OF O VI PROFILES

The High Velocity H I + O VI Sky

60% OF THE 100 EXTRAGALACTIC LINES OF SIGHT HAVE HIGH VELOCITY O VI WHICH OFTEN IS ASSOCIATED WITH H I HVCs

THE H I HVCs ARE INTERACTING WITH THE GAS IN AN EXTENDED (R >50 kpc) HOT GALACTIC CORONA
\[ \langle \log N \rangle = 13.95 \pm 0.34 \]

For SOLAR O/H
\[ \log N(O \text{ VI}) = 14.0 \]
Implies
\[ \log N(H^+) \sim 18.0 \]

SKY DISTRIBUTION OF THICK DISK N(O VI)
Savage et al. (2003, ApJS, 146, 125)
100 EXTRAGALACTIC DIRECTIONS

DISTRIBUTION IRREGULAR ~10x spread in N(O VI)
~1.8X EXCESS OF O VI IN THE NORTH
EXTENSION OF THE HIGHLY IONIZED IONS INTO THE HALO

EXPONENTIAL SCALE HEIGHTS OF THE HIGHLY IONIZED ATOMS

Si IV  5.1±0.7 kpc  HST
C IV  4.4±0.6 kpc  HST
N V  3.3±0.5 kpc  HST

O VI  2.3(south) to 4 (north) kpc  FUSE
assumes n(O VI)_o = 1.7x10^{-8} cm^{-3} from O VI disk survey (Jenkins et al. 2001)
**O VI LINE VELOCITIES**

For $|b| > 45^\circ$

$<v_{obs}> = 0 \pm 21 \text{ km s}^{-1}$(STD)

**O VI MOVES TOWARD AND AWAY FROM THE PLANE WITH EQUAL FREQUENCY**


**O VI LINE WIDTHS**

$b$ ranges from 30 to 99 km s$^{-1}$

$<b> = 60 \pm 15$(STD) km s$^{-1}$

$b = 18 \text{ km s}^{-1}$ at $3 \times 10^5 \text{ K}$

**THERMAL INFLOW OUTFLOW TURBULENCE GALACTIC ROTATION**
logN(O VI) IS POORLY CORELATED WITH OTHER ISM TRACERS INCLUDING N(H I) I(Hα) I(0.25 kev X-rays)

THE O VI DISTRIBUTION CONTAINS STRUCTURES ON SCALES >0.3°

Howk et al. (2002, ApJ, 572, 264) FOUND 3x VARIATIONS IN N(O VI) OVER 0.3° to 5° ANGULAR SCALES TOWARD THE LMC AND SMC TOWARD THE GLOBULAR CLUSTER NGC 6752 (Lehner & Howk 2004, PASP, 116, 895) ( l = 336.5 , b = -25.6, d = 3.9 kpc, z = -1.7 kpc ) NO VARIATIONS ARE SEEN OVER 0.04° to 0.2° SCALES MILKY WAY HALO OVI IS SMOOTH ON SCALES <0.2° CORRESPONDING TO A SPATIAL SCALE OF <10 pc. O VI IS VERY PATCHY ON LARGER SCALES
THE FILLING FACTOR OF O VI IN THE HALO IS SMALL

\[ \sim \text{few} \times 10^{-2} \]
\[ P/k \sim 7000-10,000 \text{ K cm}^{-3} \]

FROM O VI EMISSION vs O VI ABSORPTION

FOR 6 LINES OF SIGHT


REMOVING LOCAL BUBBLE CONTAMINATION

Robin Shelton’s talk (today)
THE ORIGINS OF THICK DISK O VI

CONDUCTIVE INTERFACES

TURBULENT MIXING LAYERS

COOLING SN BUBBLES

COOLING GALACTIC FOUNTAIN GAS
(Shapiro and Benjamin 1991, PASP, 103, 923)

For logN(O VI) = 14.1 need a flow rate of
~1.4M(Sun)[n_e(0)/10^{-3} cm^{-3}] yr^{-1}
ION TO ION RATIOS CAN BE USED TO DISCRIMINATE AMONG DIFFERENT IONIZATION MECHANISMS

Ionic ratios over 20 Km s\(^{-1}\) VELOCITY INTERVALS for 8 EXTRAGALACTIC LINES OF SIGHT

CONDUCTIVE HEATING & TURBULENT MIXING ARE CONSISTENT WITH MANY DATA POINTS
MOST BASIC CONCLUSIONS

THE MILKY WAY HAS AN INHOMOGENEOUS THICK DISK OF TRANSITION TEMPERATURE GAS EXTENDING ~2 TO 5 Kpc TO EACH SIDE OF THE GALACTIC PLANE

THE NORTHERN GALACTIC POLAR REGION HAS A 0.25 DEX ENHANCEMENT OF O VI

THE H I HIGH VELOCITY CLOUDS CONTAIN MULTIPLE GAS PHASES INCLUDING O VI, N V and C IV

THE H I/O VI HVCs IMPLY THE GALAXY HAS AN EXTENDED ( R > 50 kpc) HOT GASEOUS CORONA