# *XMM-Newton* Observations of a High-Velocity Cloud in the Magellanic Stream

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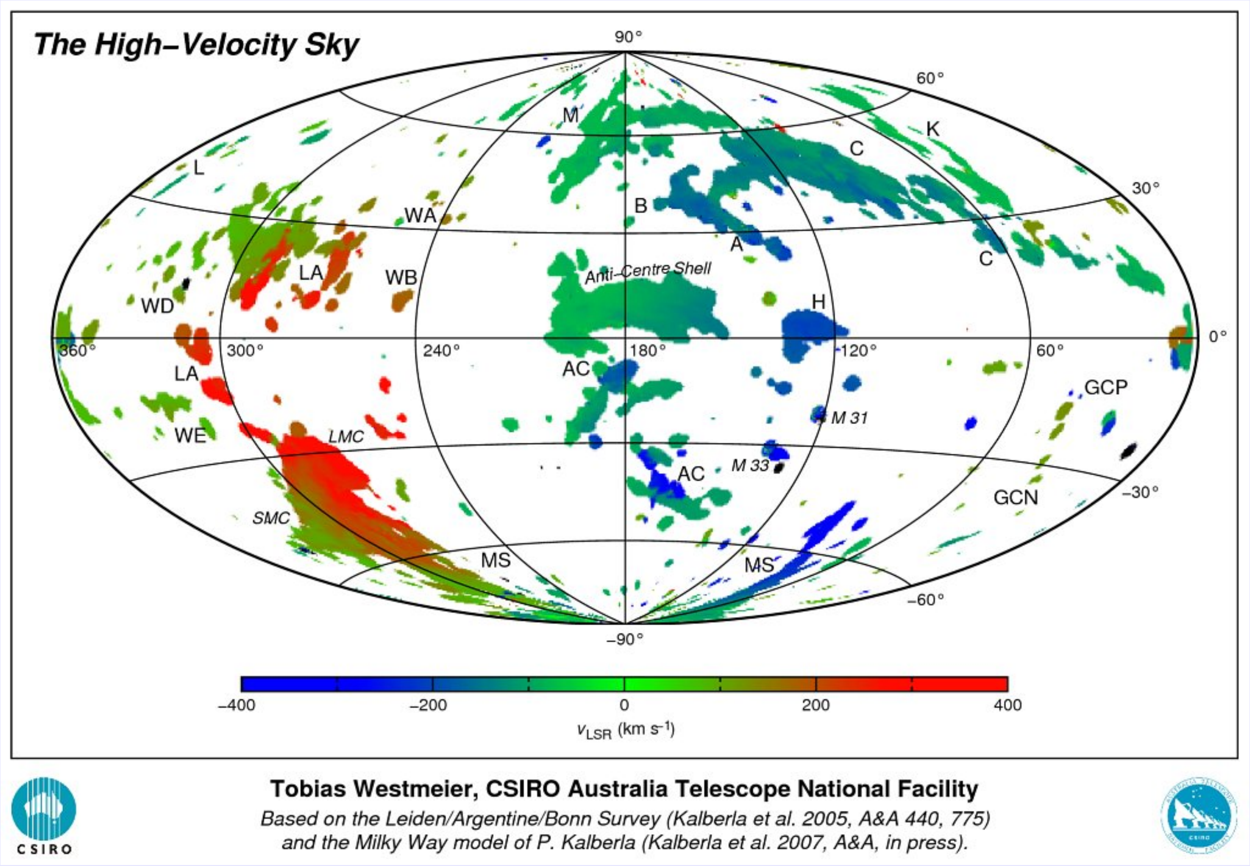
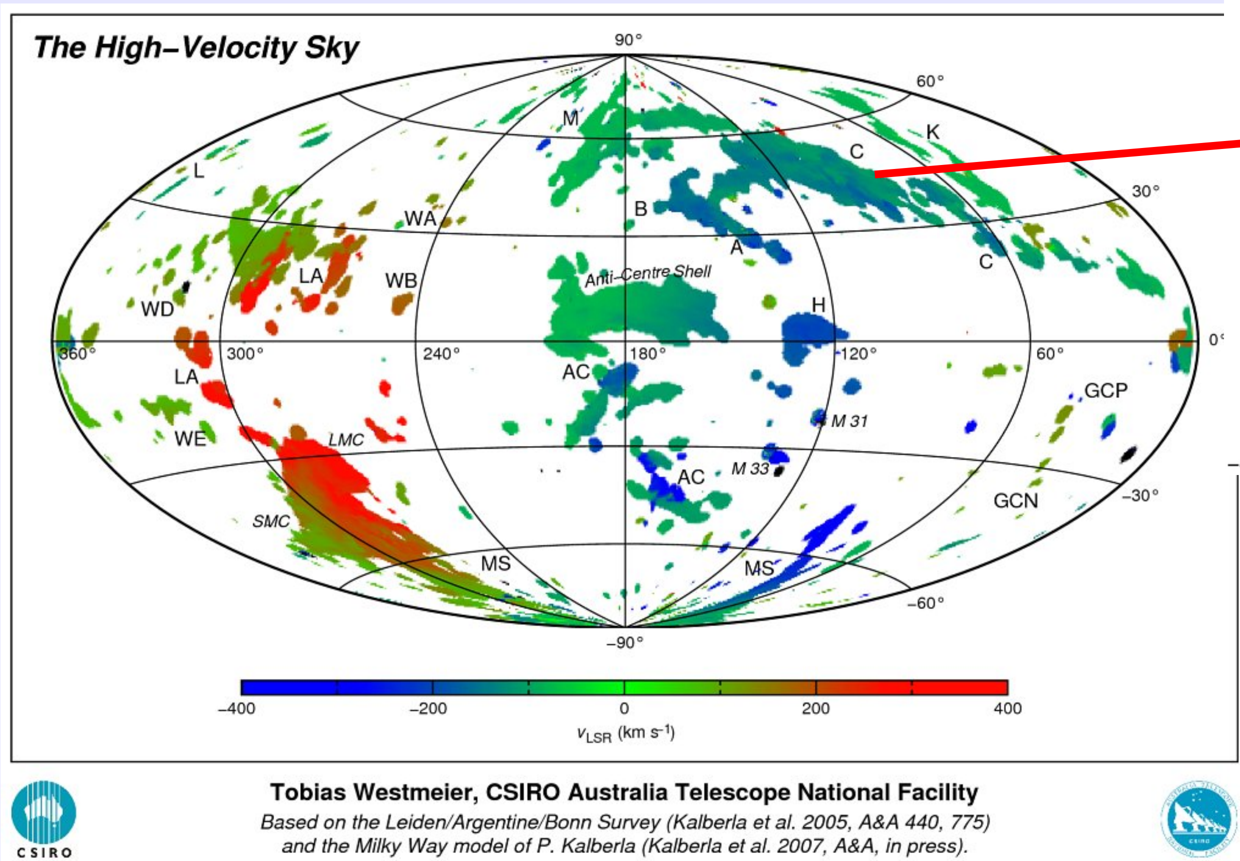
# High-Velocity Clouds (HVCs)

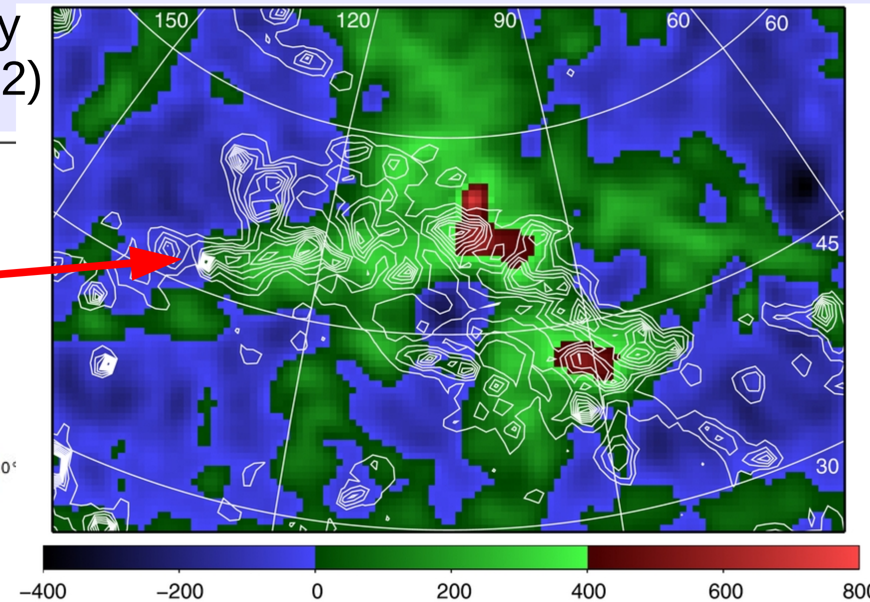



- Interstellar clouds moving at >~ 90 km $s^{-1}$ relative to LSR
- Multiple possible origins
  - Galactic fountains
  - Infalling extragalactic material
  - Material stripped from satellites

# X-rays from HVCs

Complex C – *ROSAT* All-Sky Survey
(Kerp et al. 1999; Shelton et al. 2012)




Data – Model ($10^{-6}$ counts s$^{-1}$ arcmin$^{-2}$)

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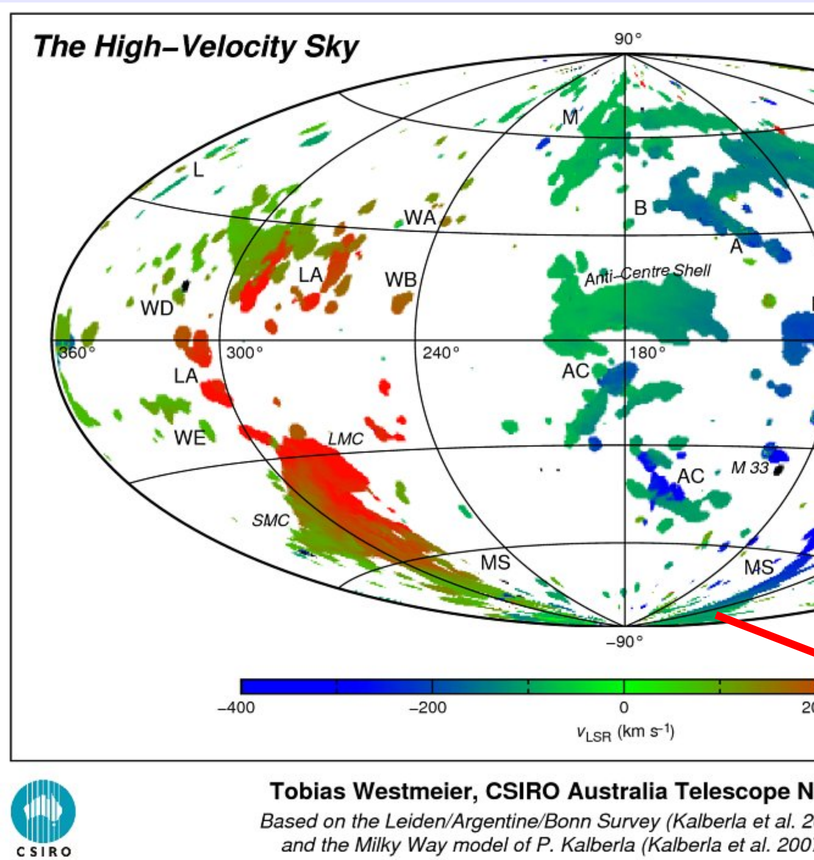


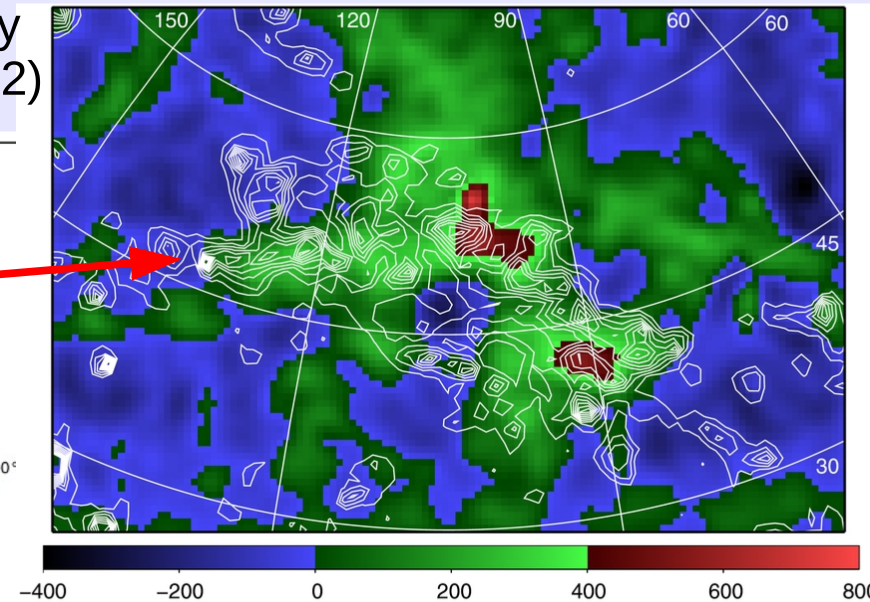


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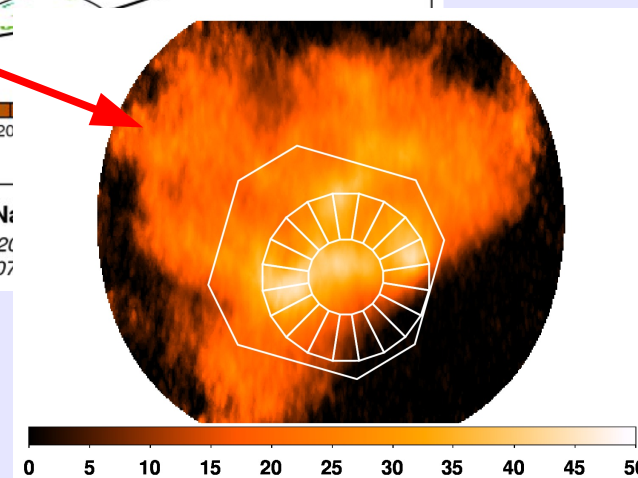
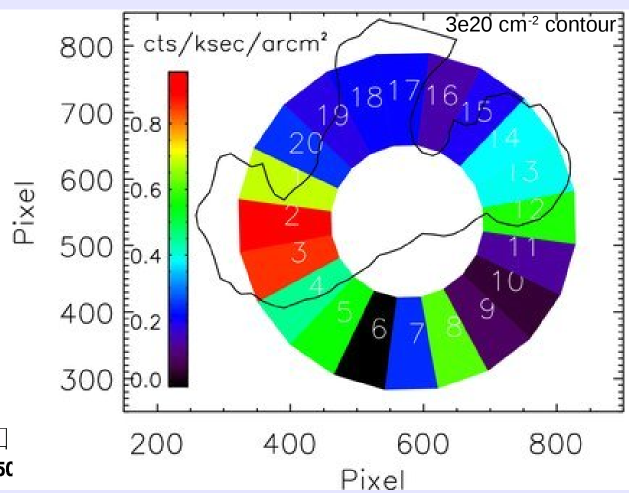


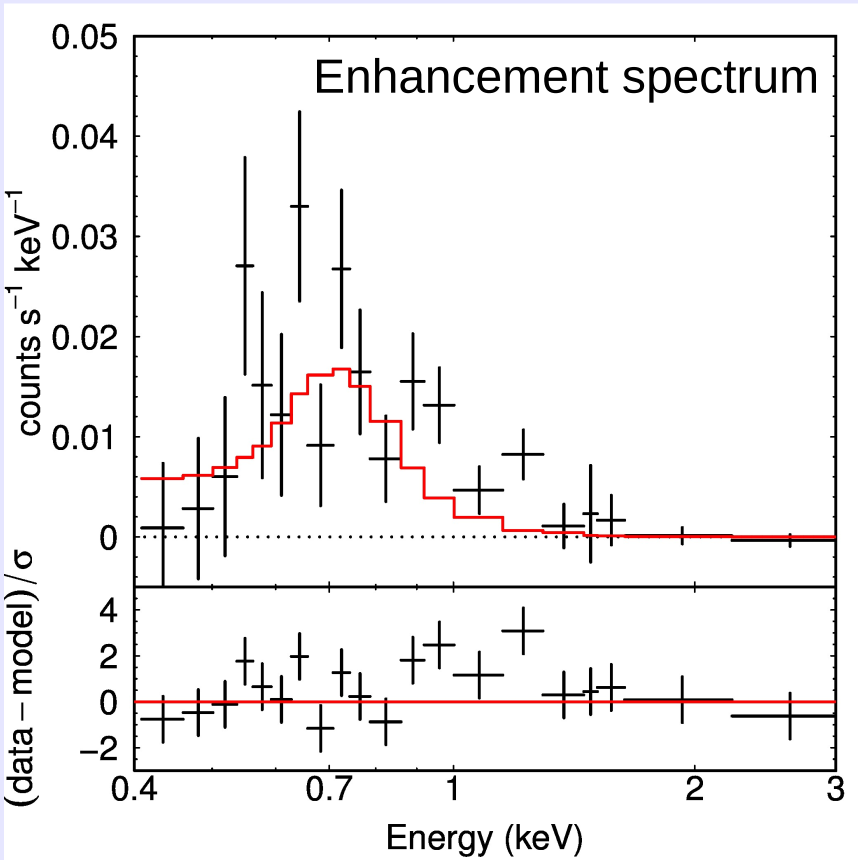

$10^{19}$ cm$^{-2}$



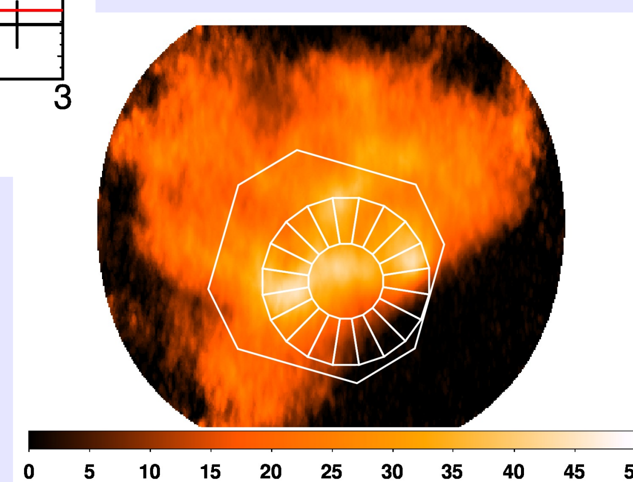

MS30.7–81.4–118 – *XMM-Newton*
(Bregman et al. 2009)

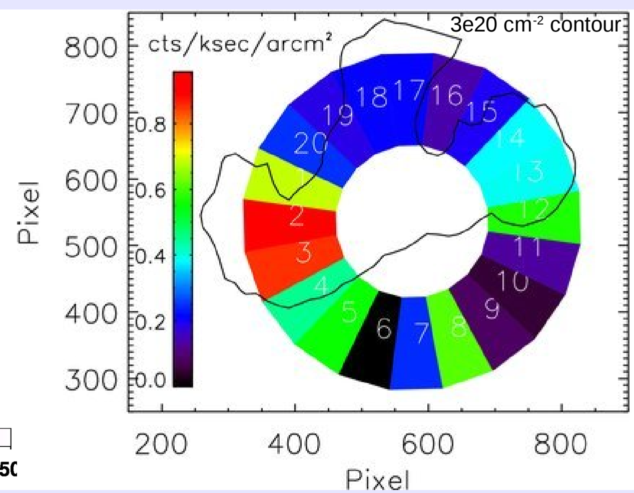
# *XMM-Newton* Spectrum of MS30.7

## (Henley, Shelton & Kwak 2014, ApJ, in press; arXiv:1406.6363)




- $T = 3.7 \times 10^6$ K
- EM = $2 \times 10^{-3}$ cm$^{-6}$ pc
- $L_{0.4\text{-}2.0} = 8 \times 10^{33}$ erg s$^{-1}$

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# Models of the MS30.7 X-ray Enhancement

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- Strong shocks
- Shock heating hot gas
- Charge exchange
- Magnetic reconnection

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| | | |
|---|---|---|
| • Strong shocks | $T \sim 2 \times 10^6$ K | Too soft |
| • Shock heating hot gas | EM $\sim 10^{-5}$ cm$^{-6}$ pc | Too faint |
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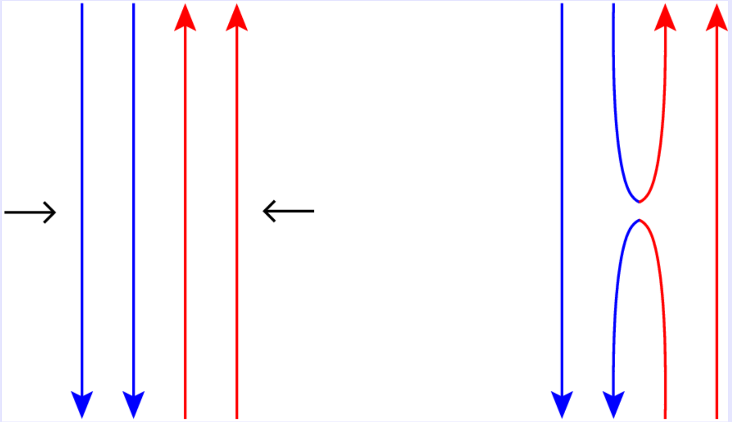
- Magnetic reconnection
  - Temperatures of several $\times 10^6$ K attainable (Zimmer et al. 1997)



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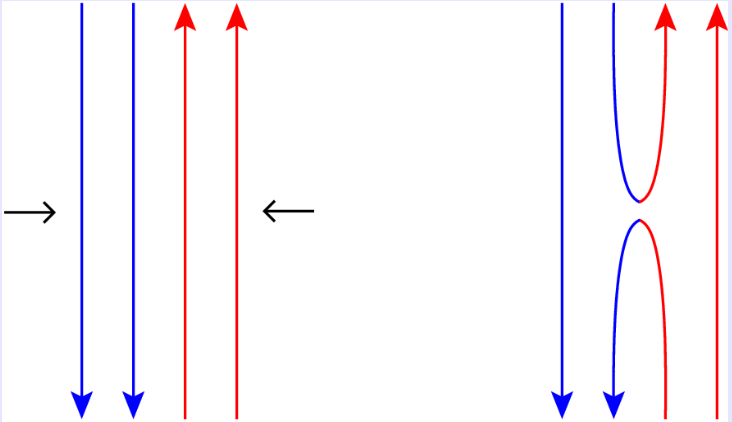
- Strong shocks    $T \sim 2 \times 10^6$ K    Too soft
- Shock heating hot gas    EM $\sim 10^{-5}$ cm$^{-6}$ pc    Too faint
- Charge exchange    $L \sim 10^{33}$ erg s$^{-1}$    Too faint
- Magnetic reconnection    $L_{mag} = (1 \times 10^{35}$ erg s$^{-1}) (B / 1\ \mu\text{G})^2$
  - Temperatures of several × 10$^6$ K attainable (Zimmer et al. 1997)
  - More than enough power available
  - Potential tool for constraining *B* in halo



# Magnetic Reconnection on Larger Scales: Elliptical Galaxies in the IGM

$$L_{\rm mag} \sim (10^{41}\ {\rm erg\ s^{-1}}) \left(\frac{B}{3\ \mu{\rm G}}\right)^2 \left(\frac{r}{20\ {\rm kpc}}\right)^2 \left(\frac{v}{200\ {\rm km\ s^{-1}}}\right)$$

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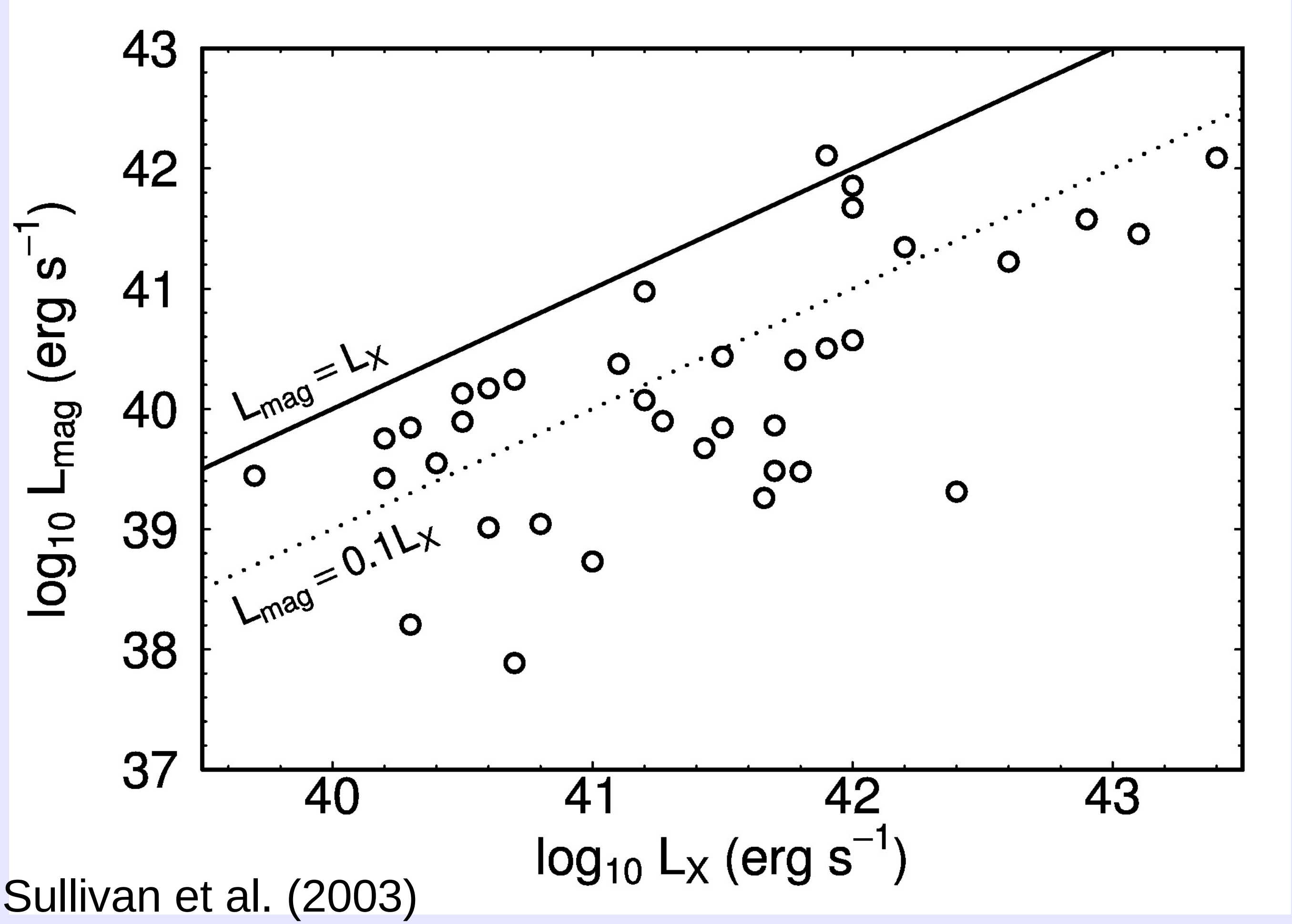


*B* = 3 μG
*v* = 200 km s$^{-1}$
$L_X$ and *r* from O'Sullivan et al. (2003)

# Summary

- X-ray enhancement observed toward MS30.7 (Bregman et al. 2009)
- *XMM* spectrum: $T = 3.7 \times 10^6$ K $L_{0.4\text{-}2.0} = 8 \times 10^{33}$ erg s$^{-1}$
- Shock heating and charge exchange cannot account for observations
- Magnetic reconnection could plausibly power emission
  - Resistive MHD simulations needed
  - Potential tool for constraining $B$ in halo
- Magnetic reconnection on galactic scales
  - If intergalactic $B$ ~ few μG, $L_{mag}$ is significant fraction of $L_X$
  - Heating via reconnection may be important on galactic scales