Extinction & Red Clump Stars

A NEW WAY TO ACQUIRE DISTANCES TO X-RAY SOURCES

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Undergraduate Research Symposium
May 8, 2008
What will be Covered

- Overview of finding distances objects
- How finding the distance to an X-ray source is different
- Show results of my part in this process
  - Finding the N-H column densities
- What’s next once distance is found?
Review: Finding Distances

- **Parallax**
- Can use the apparent (m) and absolute magnitude (M) of an optical or IR source

\[
m-M = -5+5\log(d/pc)
\]

- Have to account for interstellar dust, however:

\[
m - M_v - A_v = -5+5\log(d/pc)
\]
Finding the Distance to an X-ray Source

With X-ray sources this isn’t as straightforward

Need to:

- Measure the optical depth & convert to column density
  - Column density is the number density of that element integrated over the line of sight
  - Assume ISM (solar abundances are very similar)

- Convert column densities to an extinction value, $A_v$

- Find red clump stars along the line of sight to compare
Summary of Red Clump Stars

- Core helium-burning giants that all have about the same mass

- Luminosities are highly independent of stellar mass
  - Makes a good standard candle
    - (i.e. know the intrinsic color and absolute magnitude)

- Calculate a ladder of distances in the line of sight of the object
  - Once this is found, the reddening can also be found for each distance

- Function of reddening vs. distance along the line of sight to our source

- Fit the X-ray source in between two red clump stars to get a distance
My Part in the Process

- Analyzing Chandra spectra finding the hydrogen column density between us and the x-ray source

- The algorithm according to Durant (2008):
  - Retrieve and reduce Chandra spectra
  - fit an edge of element w/ known wavelength → absorption coefficient → column density
  - Convert column density for specific element (Mg, Si, Ne, Fe, O) to column density for Hydrogen
  - Find an average value using different elements and observations
Using calibration tools posted on Chandra website, created a “simple” bash script to automatically run through the steps.

Examined medium energy gratings (better count).

After calibrating the data, must fit the spectra:
- Edges, emission lines, absorption lines.

In order to get the process accurate use sources that have already been published and compare results for the first few times.
Sources of Interest

- **4U1728-34** – little to no literature on N-H values
- **4U1916-053** – published results but not for many elements
- **GX17+2** - little to no literature
- **EXO 0748-676** - little to no literature

Also examined:
- **4U1735-44** – used for calibration

Will show my latest results from source GX17+2
- Observations: 6630,4564,6629
Observation 6630
Obsid 6630 - Si wave band
Obsid 6630

Si edge: 6.72 Å
Obsid 6630

Mg edge: 9.5 Å
Comparing all observational results

<table>
<thead>
<tr>
<th>Observation</th>
<th>Si $(10^{22})$ cm$^{-2}$</th>
<th>Mg $(10^{22})$ cm$^{-2}$</th>
<th>Ne $(10^{22})$ cm$^{-2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>4564</td>
<td>$0.964 \pm 0.123$</td>
<td>$0.890 \pm 0.170$</td>
<td>$1.15 \pm 0.943$</td>
</tr>
<tr>
<td>6630</td>
<td>$1.41 \pm 0.150$</td>
<td>$1.35 \pm 0.189$</td>
<td>$1.25 \pm 0.940$</td>
</tr>
</tbody>
</table>

Average value from HI map$^1$ calculation $(10^{22})$: $\sim 0.905$
My average value $(10^{22})$: $\sim 1.17$

$^1$http://heasarc.gsfc.nasa.gov/cgi-bin/Tools/w3nh/w3nh.pl
Summary

- Extracted Spectra from Chandra observations of X-ray sources

- Fit Si, Mg & Ne edges
  - Obtained an absorption coefficient
  - Calculated column density for that element

- Converted column density to Hydrogen
What’s left?

- Need to look at the last observation (6629)
- Obtain a final N-H value w/ errors
- Convert to an extinction coefficient
- Compare it with a Red Clump Star

Get a distance!!!
References

Extra Slides
4564 Mg edge
6629 Mg edge
6629 Si edge