Tittle of grant: Through BAL Quasars Brightly

Type of report: Final Summary of Research

Name of principle investigator: George Chartas

Period covered by the report: 9/1/00 - 8/31/03

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The observations that were performed as part of the award titled: Through BAL Quasars Brightly, resulted in several scientific publications and presentations. We list these publications and presentations and provide brief description of the important science presented in them.

Publications :

Chartas, G., Brandt, & W. N., Gallagher, S. C. 2003, ApJ, 595, 85, *XMM-NEWTON Reveals the Quasar Outflow in PG 1115+080*

Abstract:
We report on an observation of the broad absorption line (BAL) quasar PG 1115+080 performed with the XMM-Newton observatory. Spectral analysis reveals the second case of a relativistic X-ray-absorbing outflow in a BAL quasar. The first case was revealed in a recent observation of APM 08279+5255 with the Chandra X-Ray Observatory. As in the case of APM 08279+5255, the observed flux of PG 1115+080 is greatly magnified by gravitational lensing. The relatively high redshift (z=1.72) of the quasar places the redshifted energies of resonant absorption features in a sensitive portion of the XMM-Newton spectral response. The spectrum indicates the presence of complex low-energy absorption in the 0.2-0.6 keV observed energy band and high-energy absorption in the 2-5 keV observed energy band. The high-energy absorption is best modeled by two Gaussian absorption lines with rest-frame energies of 7.4 and 9.5 keV. Assuming that these two lines are produced by resonant absorption due to Fe XXV, we infer that the X-ray absorbers are outflowing with velocities of ~ 0.10c and ~ 0.34c, respectively. We have detected significant variability of the energies and widths of the X-ray BALs in PG 1115+080 and APM 08279+5255 over timescales of 19 and 1.8 weeks (proper time), respectively. The BAL variability observed from APM 08279+5255 supports our earlier conclusion that these absorbers are most likely launched at relatively small radii of $< 10^{16}(\mathrm{Mbh/M8})^{1/2}$ cm. A comparison of the ionization properties and column densities of the low-energy and high-energy absorbers indicates that these absorbers are likely distinct; however, higher spectral resolution is needed to confirm this result. Finally, we comment on prospects for constraining the kinematic and ionization properties of these X-ray BALs with the next generation of X-ray observatories.

Chartas, G., Brandt, W. N., Gallagher, S. C., & Garmire, G. P. 2003, Astronomische Nachrichten, Vol. 324, 173, *An X-ray Survey of Gravitationally Lensed BALQSOs*

Abstract:
We report on results from a mini-survey of gravitationally lensed broad absorption line (BAL) quasars performed with the *Chandra* and *XMM-Newton* observatories. The gravitational lensing effect combined with the relatively high redshift of the sample has facilitated the acquisition of the first high signal-to-noise (S/N) X-ray spectra of BAL quasars. In all cases we find that the spectral slopes of the unabsorbed specta are consistent with those of normal radio-quiet quasars and their X-ray faintness is due to absorption with typical hydrogen column densities ranging from $\sim 10^{22}$ - 10^{24} cm^{-2}, consistent with previous observations (e.g., Green et al. 2001). In several of the BALQSOs of our sample the S/N was sufficient to allow for a more complex spectral analysis. For these systems we placed constraints on the kinematics, ionization state and geometry of BAL winds

Presentations:

Applications of Gravitational Lensing In X-ray Astronomy. presented at the 3rd International X-ray Astronomy School, 2003.

Quasar Outflows,
presented at the Goddard Space Flight Center Colloquim, August 2002.

Views of Quasar Outflows Through Natural Lenses,
presented at the High Energy Astrophysics Division Meeting, American Astronomical Society, Mt. Tremblant, Quebec, Canada, March 2003.

Recent press releases and reported articles:

Doomed Matter Near Black Hole Gets Second Lease on Life, PSU PRESS RELEASE, March 2003, by George Chartas, edited by Christopher Wanjek, NASA http://www.science.psu.edu/alert/Chartas3-2003.htm

The Give and Take of Black Holes, BBC NEWS, March 26, 2003, by Dr David Whitehouse, BBC News Online science editor, http://news.bbc.co.uk/2/hi/science/nature/2888081.stm

Cosmic Blowout: Black Holes Spew As Much As They Consume, SCIENCE NEWS, April 5, 2003, Vol. 163. No. 14, by Ron Cowen, http://www.sciencenews.org/20030405/fob7.asp

Quasars Really Blow, SCIENCE NOW, March 28, 2003, by Robert Irion

Scientists Say Black Holes May Pepper the Universe With the Stuff of Stars, POPULAR SCIENCE, July 2003, by Andrew Fazekas