ChaMPlane Chandra/HST survey of low-extinction windows in the Galactic Bulge

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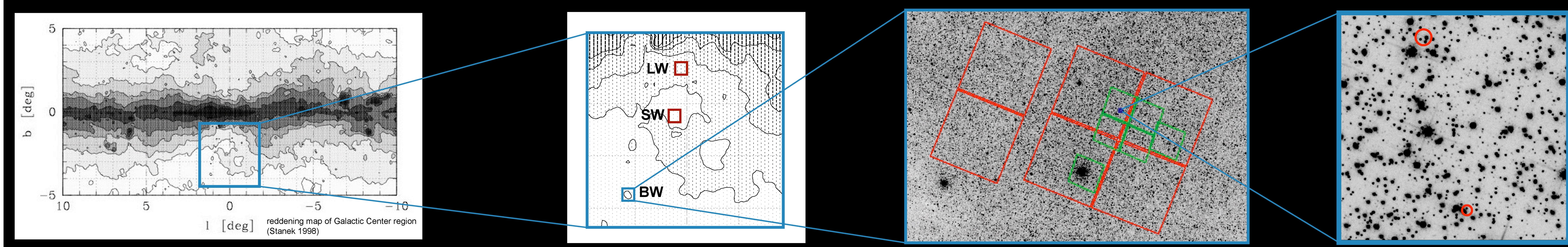
the survey



The ***Chandra Multiwavelength Plane (ChaMPlane)*** project is an extensive x-ray/optical/IR survey to study the population of low-luminosity accreting binaries in the Galactic Plane (Grindlay et al. 2005). Much of the effort is focussed at studying the Galactic Bulge and Galactic Center region where Chandra has revealed a still largely unidentified population of hard point sources (Muno et al. 2003). We are conducting an x-ray/optical survey of selected regions in the Bulge where the low extinction still allows optical follow-up studies of sources in the Bulge. Our main motivations are to study the properties of accreting binaries in the Bulge and trace the radial gradient of the intriguing Galactic Center population. See also the posters by Hong et al. and Laycock et al.

Three low-extinctions *windows* in the Bulge were selected as targets for deep Chandra/ACIS observations.

BW = Baade's Window (A_V = 1.3)
SW = Stanek's Window (A_V = 2.6)
LW = Limiting Window (A_V = 3.9)

Each field was observed for 100ks. 365 (BW), 389 (SW) and 250* (LW) sources were detected (0.3-8 keV) on ACIS-I. Near-simultaneous observations of regions close to the Chandra aimpoint** were obtained with the ACS/Wide Field Camera (0.05"/pixel) on HST (green outline in image). Ground-based imaging and spectroscopy were done to study optically bright candidate counterparts.

*excludes the 20ks observation obtained in October 2005
** plus the globular cluster NGC6522 in BW

95% confidence radii on Chandra source positions can be as low as 0.3" (Hong et al. 2005) but in these crowded fields, error circles typically contain several faint stars. We rely on special properties (variability or deviant positions in color-magnitude diagrams) to select likely counterparts.

source classification

Binaries are detected in x-rays in various stages of their evolution. X-rays trace ongoing interactions, like tidal interaction or mass transfer. The properties and relative frequencies of interacting binaries in subsequent evolutionary phases can constrain binary evolution models - one of the main motivations of ChaMPlane. Comparison of the interacting binary population in the Bulge with the local disk population or with (dynamically enhanced) globular cluster populations allows tests of binary formation scenarios.

candidate cataclysmic variables

We have identified several likely cataclysmic variables in BW and SW. The figure below shows the optical spectrum and light curve of the source marked as □ in Figs. 3 and 4.

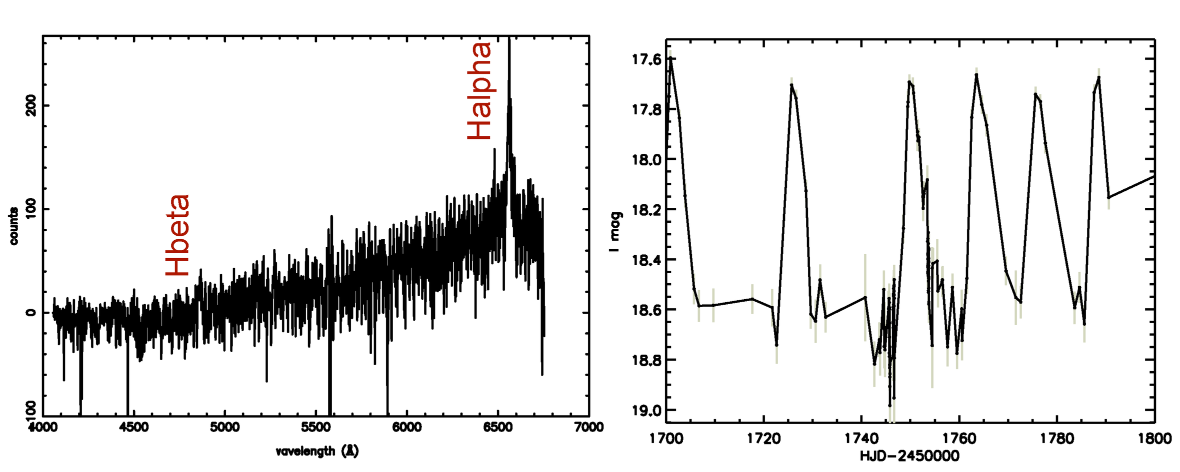


Fig. 1 Hydra spectrum (left) and OGLE light curve of a candidate cataclysmic variable in SW.

We use their typically blue colors and excess Halpha emission to identify candidate cataclysmic variables in HST/ACS images.

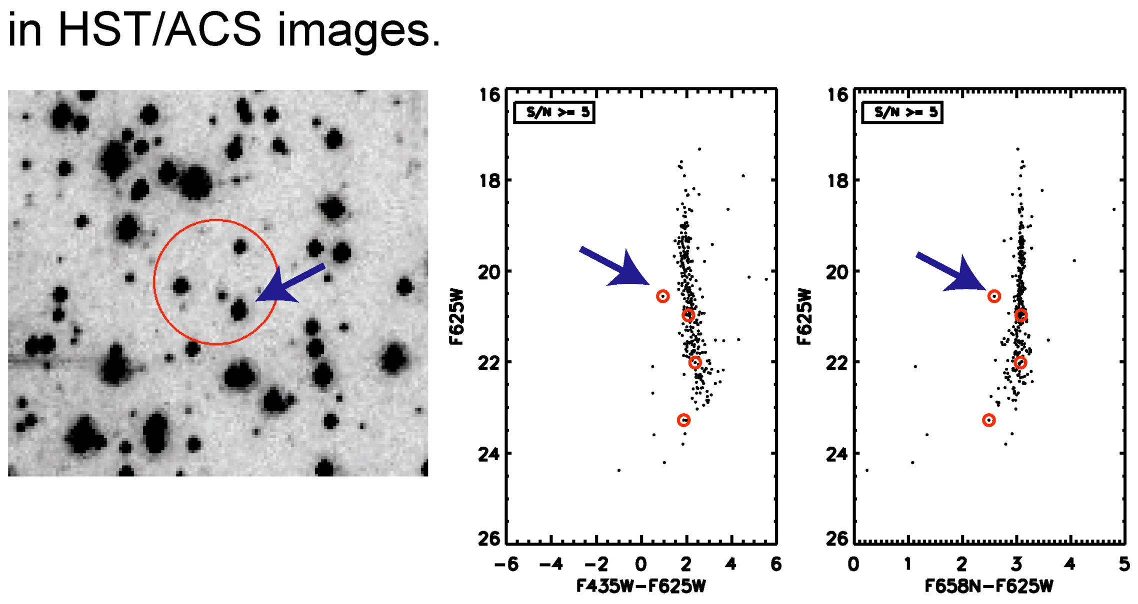


Fig. 2 *left* ACS/F625W image centered on a source in BW. The 95% confidence circle (1" radius) on the x-ray position is shown in red. *right* F435W-F625W ("B-R") and F658N-F625W ("Halpha-R") versus R color-magnitude diagrams of stars in a 20" x 20" region around this source. Stars inside the error circle are marked in red. One source stands out as being relatively blue and Halpha bright.

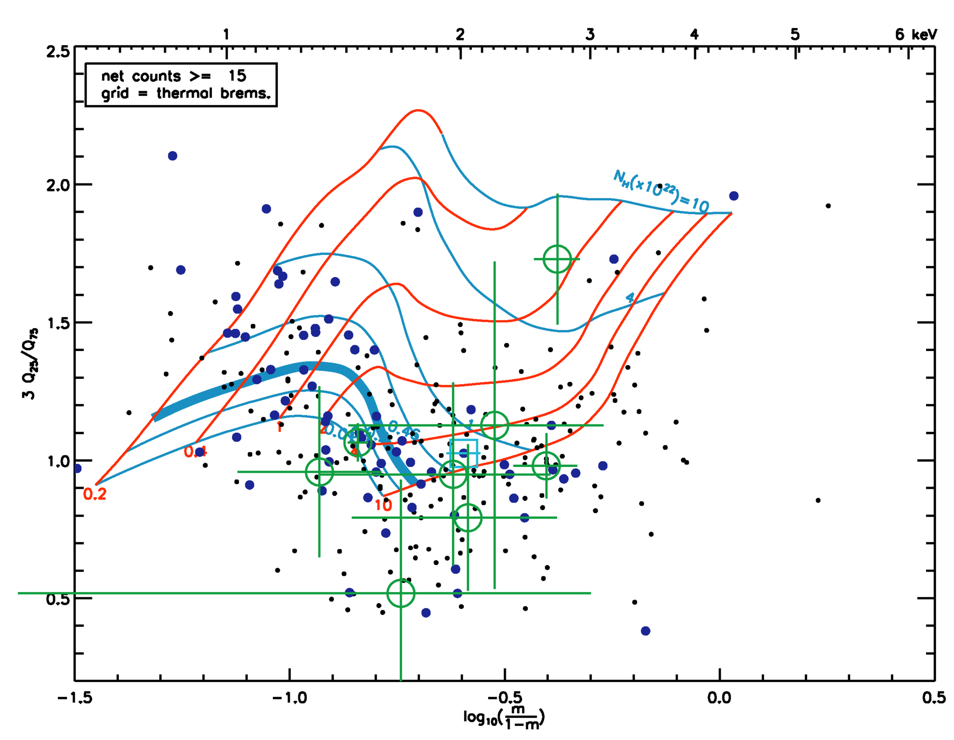


Fig. 3 Quantile color-color diagram for sources in SW with more than 15 net counts. Energy quantiles are compared with absorbed thermal bremsstrahlung models. The thick blue line indicates the average nH of the SW field (4.6 10^{21} cm^{-2}) - sources that lie significantly above this line are intrinsically absorbed (assuming thermal bremsstrahlung emission). OGLE variables are marked with ●, a candidate cataclysmic variable with □, and candidate symbiotics with ○. See Hong et al. 2005 for more on quantile analysis.

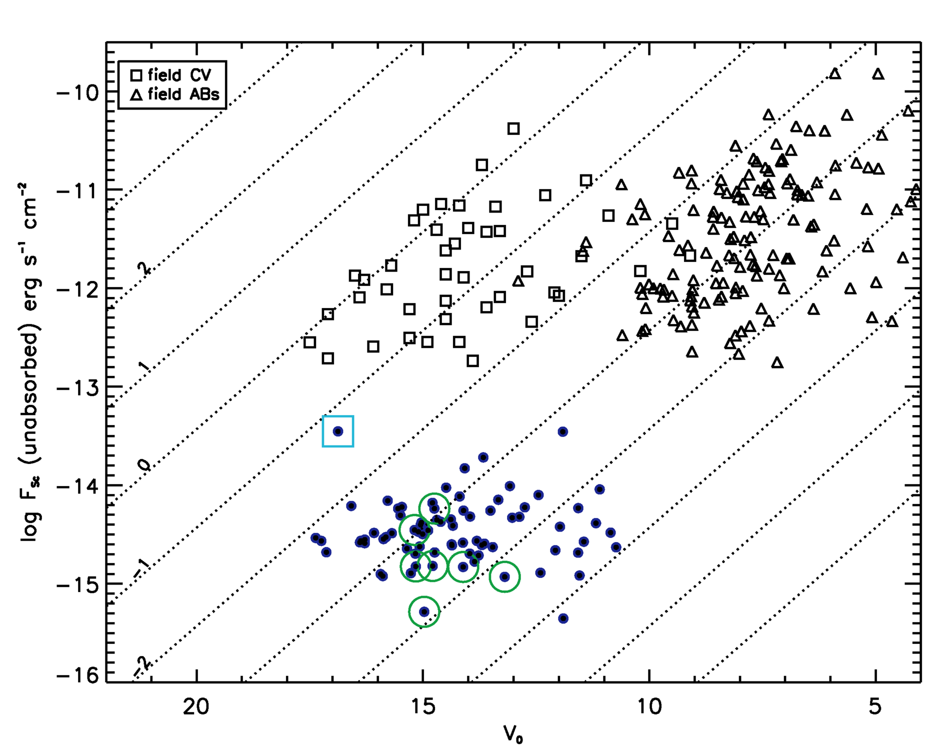


Fig. 4 X-ray (0.5-2 keV) to optical flux ratios for sources matched with OGLE variables compared to field cataclysmic variables and active binaries observed with ROSAT (Verbunt et al. 1997, Dempsey et al. 1993, 1997). Same symbols as in Fig.3.

candidate symbiotic binaries in the bulge

4 BW and 9 SW sources have M-giants in their error circles. Tests indicate this is more than expected from random coincidences. These sources typically have hard x-ray spectra and some appear intrinsically absorbed (○ in Fig. 3). With x-ray luminosities between 10^{31} and 10^{33} erg/s (0.5-8 keV; for a distance of 8 kpc), their x-ray emission is well above the measured values or upper limits for the intrinsic emission of M-giants. We suggest these sources could be symbiotic binaries where the wind of a late-type giant is accreted by a binary companion - typically a white dwarf but in some cases (e.g. GX1+4) a neutron star - and explains the enhanced absorption. Assuming mass loss rates typical for luminosity class III giants (10^{-9}-10^{-7} solar mass/year) and orbital periods typical for known symbiotic systems (100 d to a few years) we derive that absorption by the stellar wind can be sufficient to explain the excess absorption along the line of sight as derived from x-rays. These sources are too bright in the IR to explain the hard source population in the Galactic Center (see also Laycock et al. 2005).

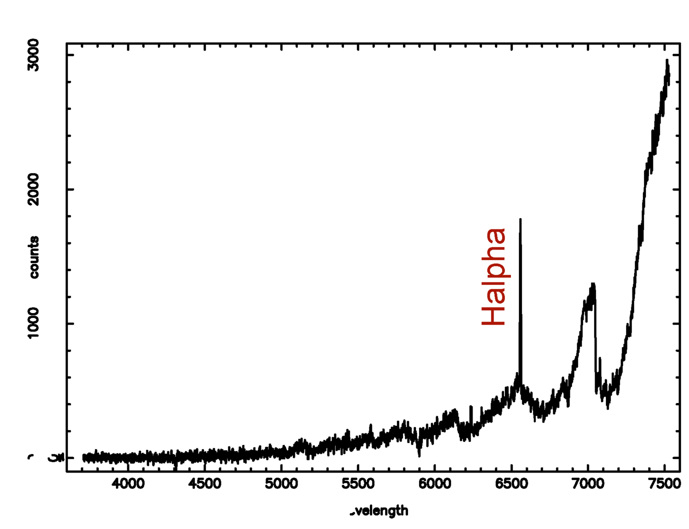


Fig. 5 Hydra spectrum of a candidate symbiotic binary in SW.

coronally active binaries

Cross-correlation of the Chandra source lists with OGLE variable catalogues has resulted in possible counterparts for 15-20% of the sources in BW and SW. Based on the optical light curves, many of the matched sources (● in Figs. 3 and 4) can be classified as close binaries (contact binaries, detached eclipsing binaries).

references
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