Accretion onto the intermediate mass black hole candidate ESO 243-49 HLX-1

Natalie Webb

irap

Toulouse, France

F. Antonini, D. Barret, S. Corbel, D. Cseh, S. Farrell, R. Fender, N. Gehrels, O. Godet, T. Kawaguchi, J.-P. Lasota, E. Lenc, D. Lin, J. Lombardi, A. Musaeva, M. Servillat, O. Straub, M. Thomas, J. Vingless

The mechanism for the formation of supermassive black holes ($10^6 - 10^{10}$ M⊙) is still unclear, but many of the theories proposed to explain their origin evoke lower mass seed black holes (intermediate mass black holes, $10^2 - 10^5$ M⊙) as their progenitors. However, the observational evidence for these intermediate mass black holes has been weak. Further, how such intermediate mass black holes can accrete sufficient matter to shine brightly has also posed problems. Here we present the best intermediate mass black hole (IMBH) candidate, ESO 243-49 HLX-1, which reaches X-ray luminosities in excess of 1×10^{42} erg s^{-1} and discuss both the accretion and ejection mechanisms that have been proposed to explain this exceptional object. We also review the available observational evidence for the origin of this system.

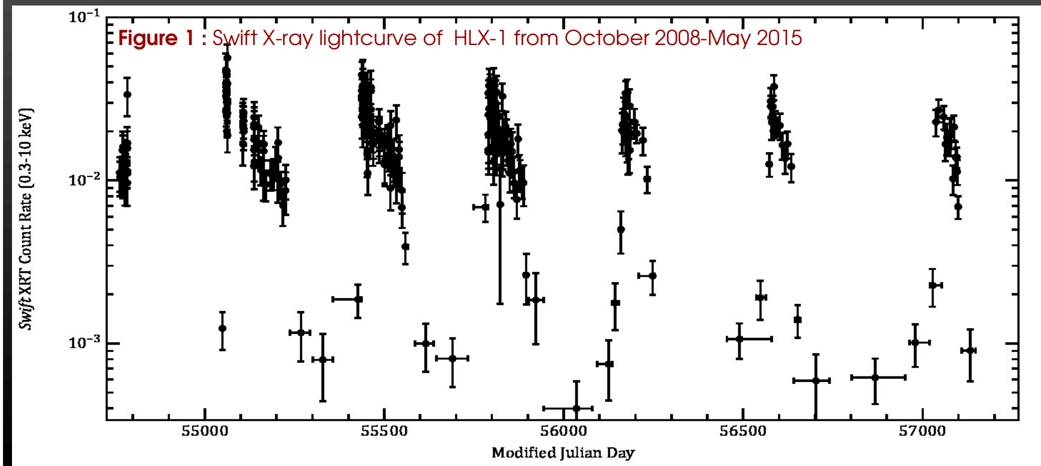


Figure 1 : Swift X-ray lightcurve of HLX-1 from October 2008-May 2015

- Eddington scaling implies black hole mass M > 500 M⊙ (Farrell et al., Nature, 2009)
- Accretion disc modelling implies ~10^3<M<10^5 M⊙ (Davis et al. 2011, Godet et al. 2012, Straub et al. 2014)
- Eddington scaling => 9×10^3<M<9×10^4 M⊙ (Webb et al. 2012)
- HLX-1 shows canonical black hole states (Godet et al. 2009, Servillat et al. 2011)
- Jet ejection events associated with low to high state transitions like black hole binaries (Webb et al., Science, 2012)
- Quasi periodic outbursts (see Fig. 1) may be due to tidal stripping of companion at periapse (Lasota et al 2011)
- Mass transfer delivery radius close to black hole, ~10^{11} cm (Webb et al. 2014)
- Newtonian Smoothed Particle Hydro-dynamic (SPH) simulations show a highly eccentric binary could form with an IMBH
- and a white dwarf-like companion. Orbital period decreases to minimum then increases due to tidal effects and increasing mass transfer, leading ultimately to ejection of donor (Godet et al. 2014 and Fig. 2).

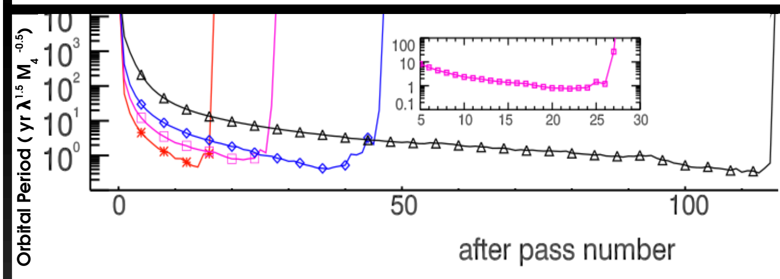
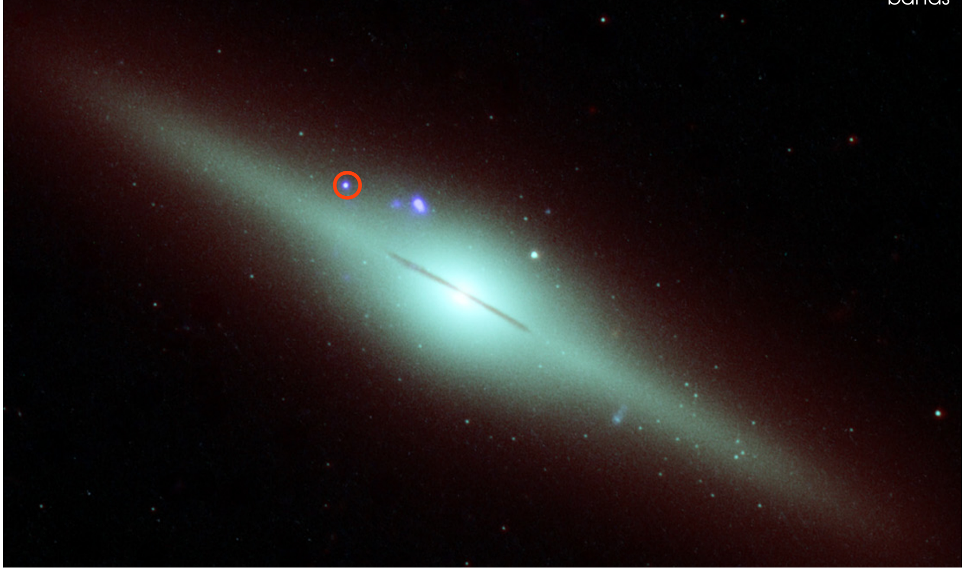


Figure 2 : Orbital evolution of a polytropic companion with n=1.5, Γ=5/3 and initial periapsis separation from the IMBH (relative to the tidal radius) of 2.3 (red), 2.4 (magenta), 2.5 (blue), 2.7 (black), λ = R/0.01R⊙ and M_4=M_{BH}/10^4 M⊙

- HLX-1 (Fig. 3) could be the remnant of a dwarf galaxy, stripped as it collided with ESO 243-49 (Webb et al. 2010, Mapelli et al. 2013)
- Possible young stellar population proposed by Farrell et al. 2012 could result from the collision
- Collision could change the orbit of stars bound to the IMBH, allowing one to form a highly elliptical binary with the IMBH
- No H I line emission detected in ESO 243-49 with M <10^8 M⊙ (5 sigma), possibly due to the cluster environment depleting gas (Musaeva et al. 2015)
- Origin of HLX-1 will be tested using MUSE data taken in August 2014 (see also poster by Adrien Detoeuf) and SPH simulations

Figure 3: ESO 243-49 and HLX-1 (orange circle), HST image composed of FUV, NUV, C, V, I, H bands



Davis, S. W., Narayan, R., Zhu, Y., Barret, D., ...Webb, N. A., 2011, ApJ, 734, 111
Farrell, S. A., Webb, N.A., Barret, D., Godet, O., Rodrigues, J.M, 2009, Nature, 460, 73
Farrell, S.A., Servillat, M., Pforr, J....Webb, N.A., et al, 2012, ApJL, 747, 13
Godet, O., Barret, D., Webb, N. A., Farrell, S. A., Gehrels, N., 2009, ApJ, 705, L109
Godet, O., Plazolles, B., Kawaguchi, T., Barret, D....Webb, N.A, et al, 2012, ApJ, 752, 34
Godet, O.; Lombardi, J. C.; Antonini, F.; Barret, D.; Webb, N. A. et al., 2014, 793, 105
Lasota, J.-P., Alexander, T., Dubus, G., Barret, D.,...Webb, N. A., 2011, ApJ, 735, 89
Mapelli, M., Annibali, F., Zampieri, L., Soria, R., 2013, MNRAS, 433, 849
Musaeva, A., Koribalski, B. S., Farrell, S. A.,...Webb, N.A., et al. 2015, MNRAS, 447, 1951
Servillat, M., Farrell, S. A., Lin, D., Godet, O. Barret, D., Webb, N. A., 2011, ApJ, 740
Straub, O., Godet, O., Webb, N.A., Servillat, M., Barret, D., 2014, A&A, 569, 116
Webb, N. A., Barret, D., Godet, O., et al., 2010, ApJ, 712, L107
Webb, N. A., Cseh, D., Godet, O., et al. 2012, Science, 341
Webb, N. A., Godet, O., Wiersema, K., Lasota, J.-P., Barret, D., et al., 2014 , ApJ, 780, L9