Mysteries of the intermediate-mass BH HLX1

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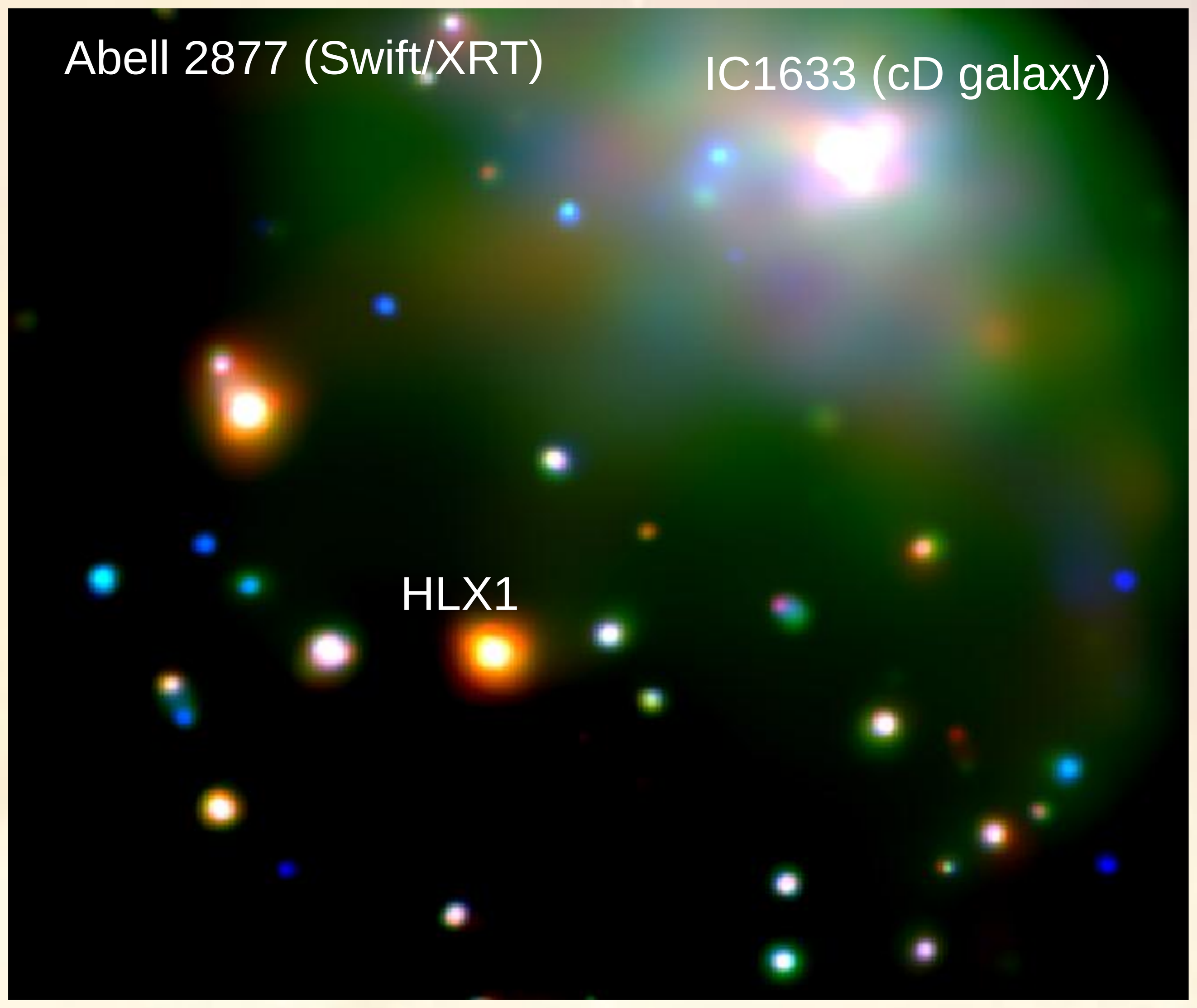
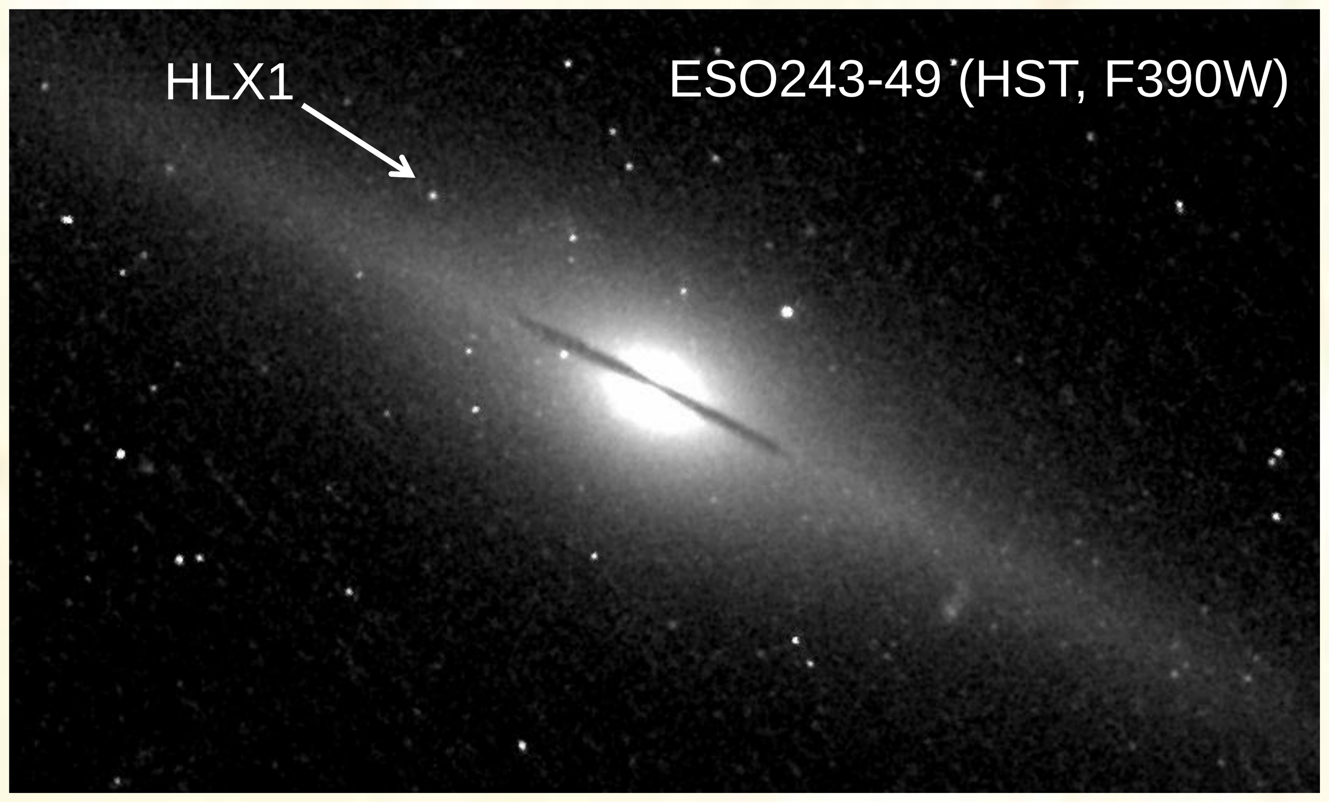
Optical counterpart of HLX1

HLX1 is located in ESO243-49, an S0 galaxy at the outskirts of Abell 2877 (d ~ 95 Mpc). This cluster contains several examples of interacting or merging galaxies. HLX1 might be the nuclear BH of a stripped dwarf accreted by ESO243-49 (Mapelli et al 2012).



The optical counterpart was observed with HST, one month after the peak of the 2010 outburst (Farrell et al 2012), and with VLT, three months after the peak (Soria et al 2012). The AB magnitudes were:

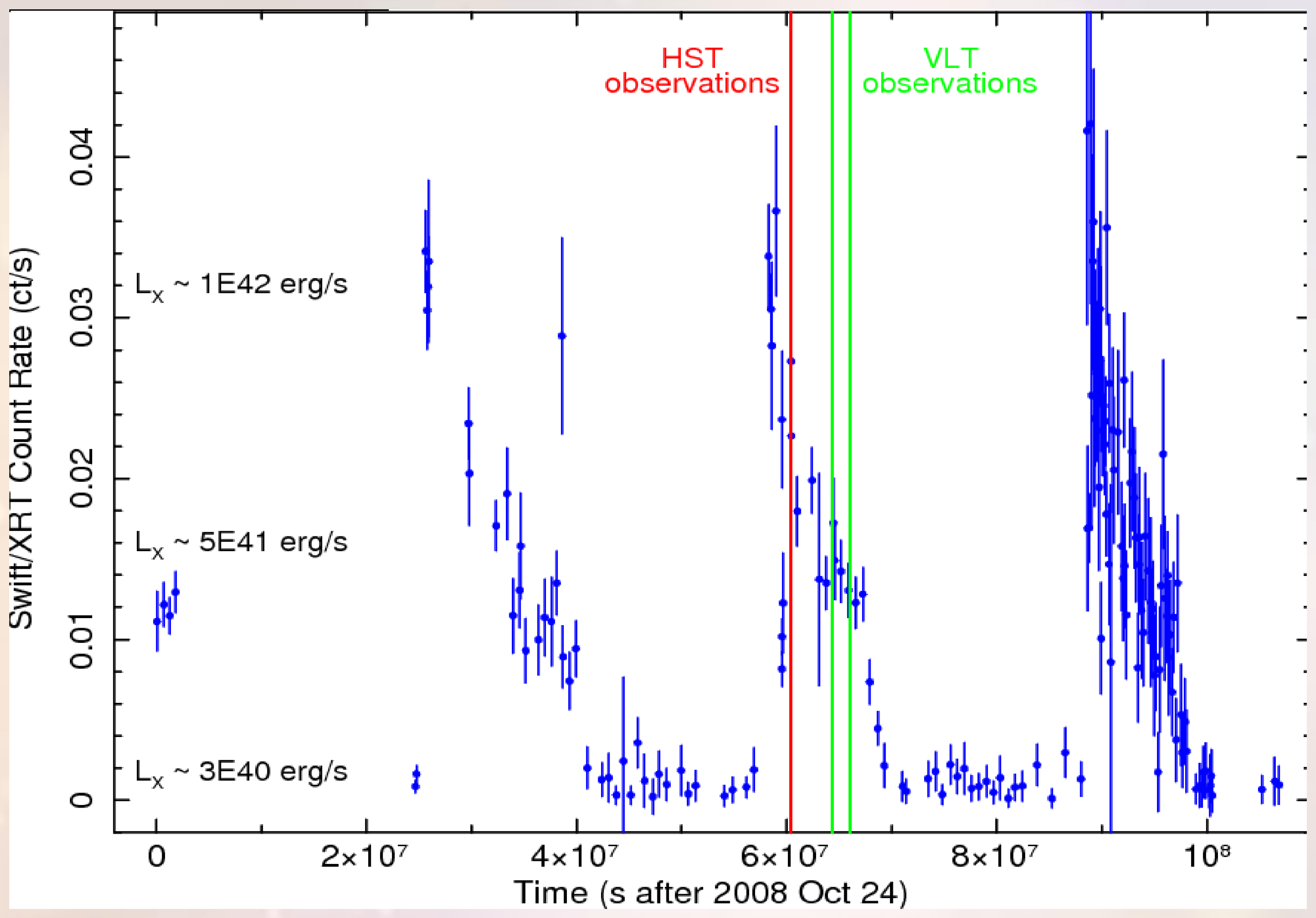
Filter	HST (09/2010)	VLT (11/2010)
F140LP	24.11 +/- 0.05	-
F300X	23.96 +/- 0.04	-
U	-	24.67 +/- 0.18
F390W	23.92 +/- 0.06	-
B	-	24.99 +/- 0.30
V (F555W)	23.83 +/- 0.08	24.81 +/- 0.34
R	-	24.87 +/- 0.40
I (F775W)	23.91 +/- 0.08	> 25



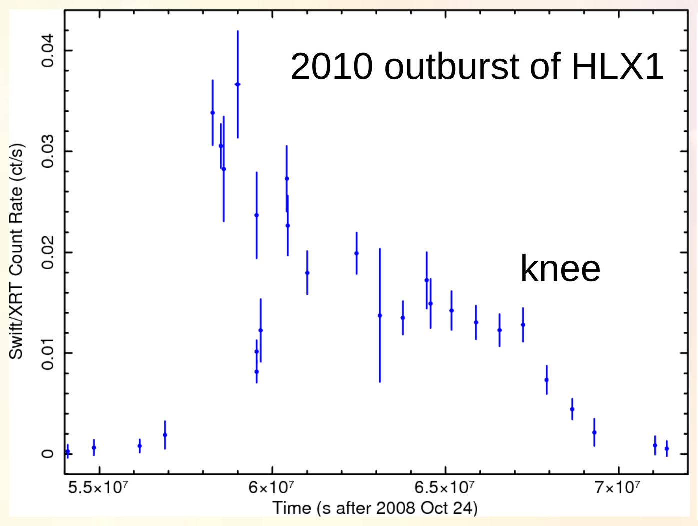
The decline proves that most of the optical flux near outburst peak comes from the irradiated disk (and donor star), not from a massive star cluster.

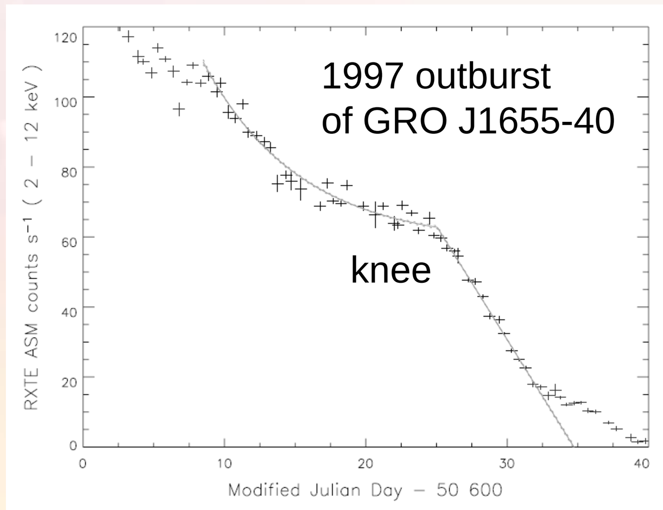
Donor star, disk size and mass ratio

Outbursts seem to repeat every ~366 +/- 4 days. The plot below shows the *Swift*/XRT 0.3-10 keV lightcurve and the epochs of Farrell's HST observation and our VLT VIMOS data in the 2010 campaign.

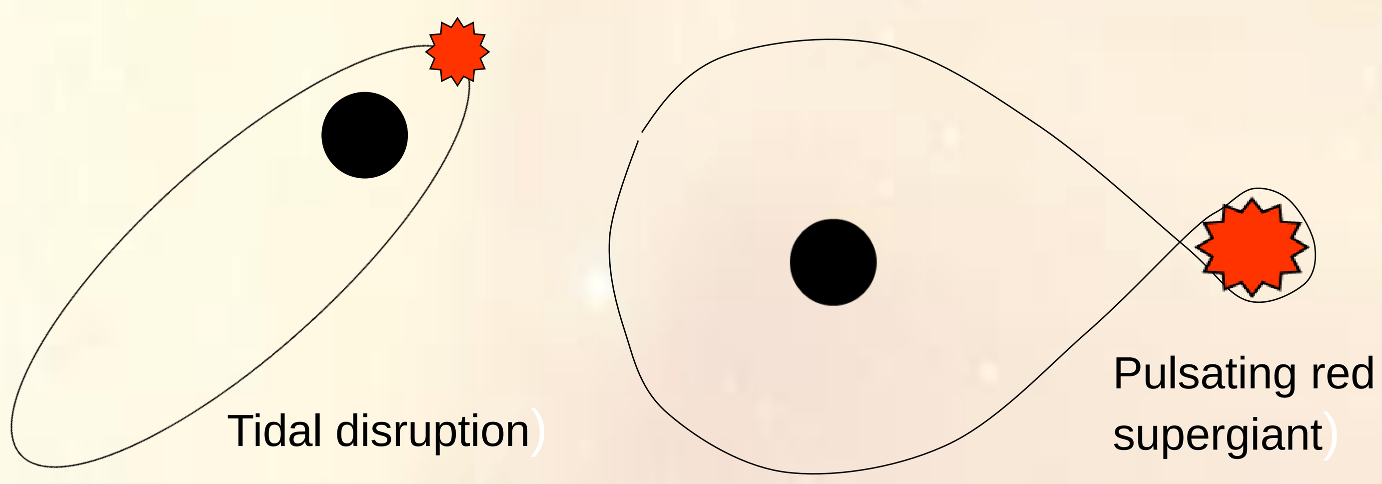


The *shape* of each outburst is similar to those of Galactic BH transients with a low-mass donor star: **fast rise, early phase of exponential decay, "knee", linear decline.** The knee occurs when the outer disk starts to become neutral (T <~ 8000 K). From the X-ray luminosity at the knee, using Galactic BH scalings (Powell et al 2007, MNRAS, 374, 466), we estimate an outer disk radius ~ 1E13 cm, **an order of magnitude smaller than expected** for a 1E4 Msun BH in a 366 day orbit. The peak-to-knee time interval of ~ 3-5 months (~ viscous timescale) is also much less than expected for a system of that mass and period.



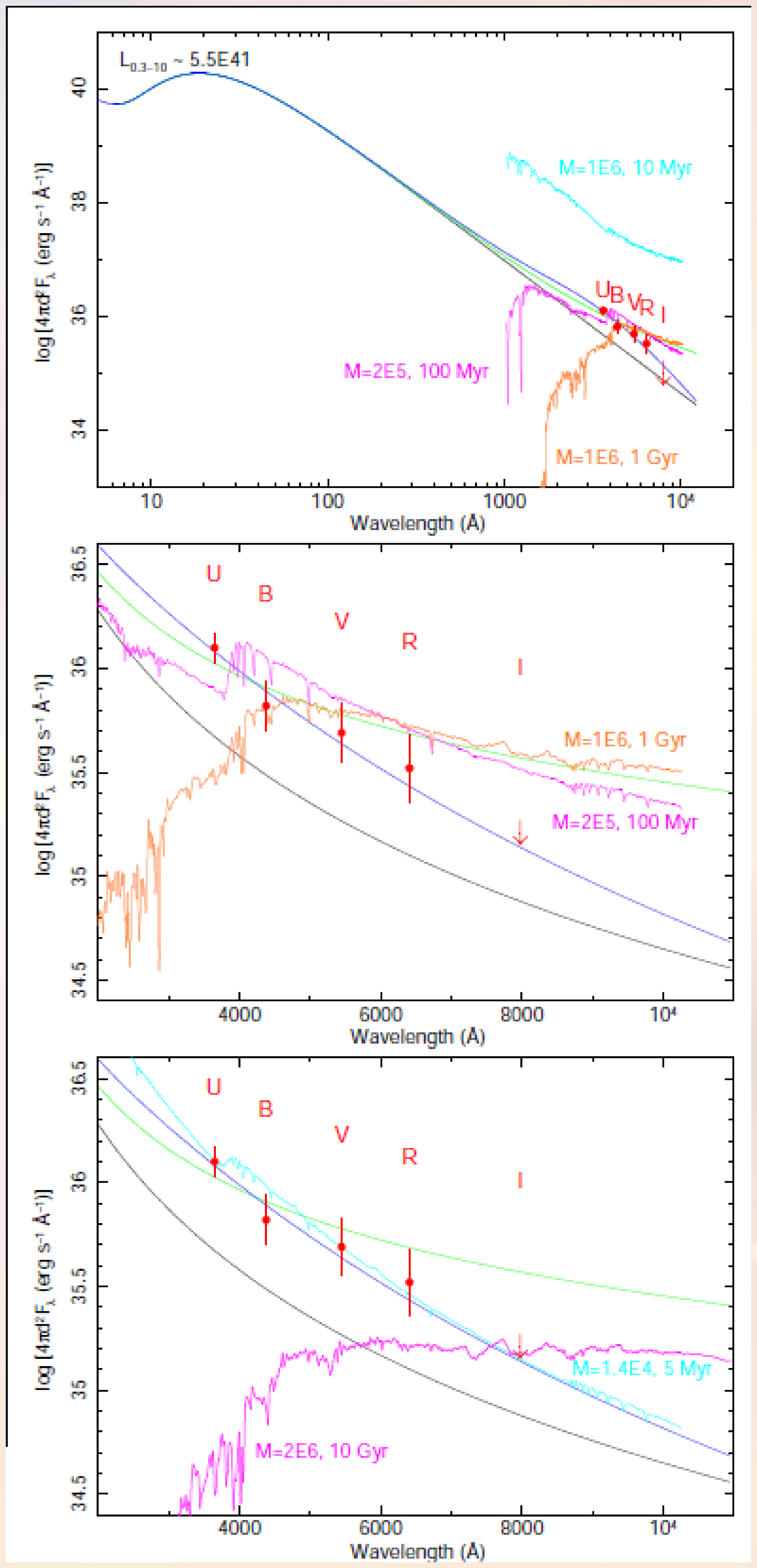


One scenario for mass transfer is a donor star on a very eccentric orbit, that gets very close to its tidal disruption radius at periastron (Lasota et al 2011). We propose an alternative scenario: **a supergiant star on a circular orbit, pulsating with P ~ 366 d, filling its Roche Lobe and increasing mass transfer once every pulsation.**



Optical emission: BH disk or star cluster?

One month after the peak (HST data, Sep 2010), the UV/optical flux is entirely dominated by the irradiated disk. Two months later, it may still be the disk, or a small population of young stars (young cluster mass <~ 1E4 Msun). A young super-star cluster is ruled out. IR imaging in quiescence are needed to test the presence of an old (~10 Gyr), massive globular cluster.



From our X-ray/optical SED, we find an outer radius of the irradiated disk ~ 2E13 cm (also in agreement with the results of Farrell et al 2012 from their HST data). This is only < 0.1 of the Roche lobe radius or tidal disruption radius, for a 10^4 Msun BH (as suggested by the *inner* disk radius). **Why is the disk so small?** Are we overestimating the BH mass or the binary period?

More details in Soria et al 2012, MNRAS, 420, 3599 **(contact roberto.soria@icrar.org)**

Other references on the optical counterpart:
Farrell et al 2012, ApJ, 747, L13 --- Lasota et al 2011, ApJ, 735, 89 --- Mapelli et al 2012, MNRAS, accepted (arXiv:1203.4237) --- Soria et al 2010, MNRAS, 405, 870 --- Wiersema et al 2010, ApJ, 721, L102