



Estimation of mass of MAXI J1659-152 during its very first outburst with TCAF fits

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Abstract. We determine mass of MAXI J1659-152 using two different methods, viz: constant Normalization parameter point of view while fitting with TCAF, $M_{BH}-\chi^2_{red}$ variation from TCAF fits. We find a mass range of $4.06 - 7.93 M_{\odot}$ with a most probable value at $6 \pm 2 M_{\odot}$.

Keywords : X-rays: binaries – stars:individual:MAXI J1659-152 – black hole physics – radiation mechanisms: general

1. Introduction

MAXI J1659-152 was first observed by MAXI/GSC instrument on 24th Sept. 2010 at the sky location of R.A. = $16^h 59^m 10^s$, Dec = $-15^{\circ} 16' 05''$ (Negoro et al. 2010). It showed its very first outburst in 2010, other than low-level activity in 2011 which continued for ~ 9 months. The most acceptable ranges of distance and disk inclination angle are 5.3 – 8.6 kpc and 60 – 80 deg. (Yamaoka et al. 2012 and Kuulkers et al. 2013) respectively. Mass of the black hole candidate is estimated to be in the range 3.6 – 8 M_{\odot} (Yamaoka et al. 2012), 2.2 – 3.1 M_{\odot} (Kenna et al. 2011), $20 \pm 3 M_{\odot}$ (Shaposhnikov et al. 2011).

2. Results and Concluding remarks

In Fig. 1a we see that the value of normalization parameter (61.94-86.71) remains at about a constant value (≈ 70) throughout the outburst as it should be. During the fitting we tried to fit data with acceptable reduced χ^2 keeping Normalization roughly constant. This leads to a narrow range of possible mass of the black hole. During fitting if we keep our all parameters to be free and maintain the normalization parameter to be constant, we find mass of black hole in the range of $5.14-7.93 M_{\odot}$.

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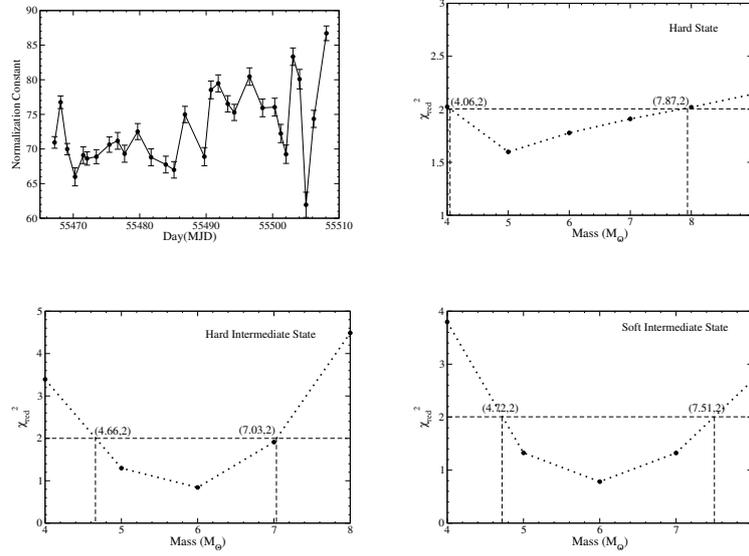


Figure 1. (a) Variation of normalization parameter with day, which is roughly constant (≈ 70) over the entire outburst. In figure b, c and d the Variation of reduced χ^2 with mass of black hole (M_{BH}) in solar mass (M_{\odot}) unit for different spectral states are shown, value of reduced χ^2 remains good in between mass range $4.06M_{\odot}$ - $7.87M_{\odot}$ beyond which value of reduced χ^2 is >2 .

In the second method, we fit 30 observation Ids with TCAF (Chakrabarti and Titarchuk, 1995) model after the inclusion in XSPEC (Debnath et al. 2014). During fitting we keep all the parameter free. After achieving the best fit (for details, see, Debnath et al. 2015) we freeze all the parameter except the mass of black hole and tried to find the range of mass within which, value of reduced χ^2 is acceptable (<2). In Fig. 1(b-c) we see that value of reduced χ^2 behaves well within a mass range of 4.06 - $7.87M_{\odot}$. So, from variation of $M_{BH}-\chi_{red}^2$ behaviour we can bracket the mass of black hole within mass range of 4.06 - $7.87M_{\odot}$.

Combining the results of these two different types of estimates we obtain a single set of bounds for the mass. The most probable mass of black hole candidate MAXI J1659-152 appears to be $6 \pm 2 M_{\odot}$.

References

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