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The high energy view of NGC 6388: hints for an IMBH?

A.A. Nucita[1], F. De Paolis[1], R. Saxton[2], A.M. Read[3], G. Ingrosso[1], and L. Manni[1]

[1] Department of Mathematics and Physics "Ennio De Giorgi", University of Salento, Via per Arnesano, CP 193, I-73100, Lecce, Italy & INFN, Sez. di Lecce, Italy
e-mail: nucita@le.infn.it
[2] European Space Astronomy Centre, SRE-O, P.O. Box 78, 28691, Villanueva de la Cañada (Madrid), Spain
[3] Department of Physics and Astronomy, Leicester University, Leicester LE1 7RH, U.K.

Abstract. Optical observations suggest that the globular cluster NGC 6388 may harbor a central intermediate-mass black hole with mass of about 5.7×10^3 $M_\odot$. We review the past X-ray and radio observations conducted towards NGC 6388 with particular attention to the high energy transient IGRJ17361-4441 recently obsereved by INTEGRAL satellite.

Key words. Galaxy: globular clusters: individual: NGC 6388 – X-rays: general

1. Introduction

In the last decade, several evidences have been accumulated about the existence of intermediate-mass black holes (IMBHs) with mass $10^2 - 10^5$ $M_\odot$ in the center of many globular clusters: suspects come from the extrapolation to globular clusters of the M_{BH}-$M_{\rm Bulge}$ relation found for super massive black holes in galactic nuclei (Magorrian et al. 1998) and from the study of the central velocity dispersion of stars in specific targets. NGC 6388 has been recognized to be one of the best candidates to host an IMBH (Baumgardt et al. 2005). By studying the globular cluster optical photometry, Lanzoni et al. (2007) claimed the existence of a central IMBH with mass $\simeq$ 5700 $M_\odot$. Nucita et al. (2008) searched for signatures of such IMBH in archival *XMM-Newton* and Chandra data and indentified at least 16 *X*-ray sources within the half mass radius ($\simeq 40''$, see Lanzoni et al. 2007) of the cluster. The 3 sources close to the gravitational center were not spatially resolved by these authors, so that they were considered virtually as a single source (labeled as #14*) with an unabsorbed luminosity of $L_{0.5-7\ keV} \simeq 3 \times 10^{33}$ erg s^{-1}. A more detailed analysis on the same Chandra data set was conducted by Cseh et al. (2010) who removed the pixel randomization so that source #14* was resolved in three separated sources labeled as #12, #7 and #3, respectively. Cseh et al. (2010) noted that source #12 (the one closest to the NGC 6388 center of gravity) is characterized by an unabsorbed intrinsic luminosiy of $L_{0.5-7\ kev} \simeq 8.3 \times 10^{32}$ erg s^{-1}. These authors, when searching -via the ATCA facility- for a radio counterpart of the putative IMBH, were able to set only an an upper limit to the radio flux at 5 GHz of $\simeq$ 81 μJy/beam which correponds to a limit radio lu-

Send offprint requests to: A.A. Nucita minosity of $L_R < 8.4\times10^{28}$ erg s^{-1}. Thus, using the fundamental plane of black hole accretion (Merloni et al. 2003) and the observed X-ray and radio luminosities, it was possible to put a limit of $\simeq$ 1500 M$_\odot$ on the mass of the IMBH in NGC 6388 (Cseh et al. 2010). This estimate has to be taken with caution for two reasons: *i*) the identification of any X-ray counterpart of such IMBH is not trivial since several sources are close to the NGC 6388 center of gravity *ii*) the fundamental plane relation is not tested for black hole masses in the range of interest for IMBHs.

On 11 August 2011, Gibaud et al. (2011) reported the discovery of a new hard X-ray transient (IGRJ17361-4441) by the IBIS/ISGRI telescope onboard the *INTEGRAL* satellite. The source (possibly located at the cluster center) was described by a power law with photon index $\Gamma = 2.6^{+1.0}_{-0.7}$ and integrated flux of $F_{20-100\ keV} \simeq 9.7\times10^{-11}$ erg cm^{-2} s^{-1}. Since the source is possibly associated to the IMBH in NGC 6388, IGRJ17361-4441 became the target of several X-ray and radio follow-up observations (with Swift/XRT, Chandra and ATCA). A detailed analysis on the Swift/XRT, Chandra and ATCA data was conducted by Bozzo et al. (2011): these authors found that whitin the error circle of Swift/XRT the transient source is consistent with the center of gravity of NGC 6388: following the same procedure as in Cseh et al. 2010 and using the 2005 Chandra X-ray flux estimate (source #12) together with the updated ATCA radio observation, Bozzo et al. (2011) found a new IMBH upper limit of $\simeq$ 600 M$_\odot$. However, as these authors clearly stressed, the new Chandra refined target coordinates allow to consider the source as a genuine new X-ray transient formally not associated with any IMBH. Another caveat on this conclusion is necessary: in case the nature of IGRJ17361-4441 as a new transient is confirmed, one should not use the black hole fundamental plane relation in order to estimate the IMBH mass. In addition, if one believes that the transient is associated with the NGC 6388 center of gravity, then it should also be noted that at least three sources (those labeled as #12, #7 and #3 in Cseh et al. 2010) are within the error box of Swift/XRT. In particular, sources #12 and #7 have fluxes of $\simeq 4.0\times10^{-14}$ erg cm^{-2} s^{-1} and $\simeq 6.9\times10^{-14}$ erg cm^{-2} s^{-1}, respectively. If source 7 is associated with the IMBH, the X-ray and radio observations together with the fundamental plane relation give an upper limit of $\simeq$ 1200 M$_\odot$. Due to the scheduled observation program, the XMM-Newton satellite observed twice the region of the sky around NGC 6388. The observations were taken on September 1st 2011 at 13:10:34 and 19:00:17 (UT), i.e. 15 days after the first Swift/XRT follow-up observation of IGRJ17361-4441 so that the transient source was then observed serendipitously for $\simeq$ 7.6 s and $\simeq$ 7.7 s in the two slew observations with the EPIC/PN instrument (Nucita et al. 2011). These authors found an unabsorbed X-ray flux of $F_{0.5-10\ keV} \simeq 4.5\times10^{-11}$ erg cm^{-2} s^{-1} which is consistent with that observed by the Swift/XRT satellite 15 days earlier. The photon index seems to be marginally consistent ($\Gamma \simeq 0.93 - 1.63$) with that derived from the previous high energy observations. An alternative to the IMBH scenario is that the transient source is a common LMXB. This may be supported by the X-ray luminosity ($\simeq 9.3\times10^{35}$ erg s^{-1}) and by the soft spectrum observed in the XMM-Newton slew observation which seems to be consistent with the typical characteristics of the LMXB class of objects. We requested and obtained a long (1 Ms) INTEGRAL observation in order to go insight the nature of IGRJ17361-4441.

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