Gigantic mirror for X-radiation in outer space

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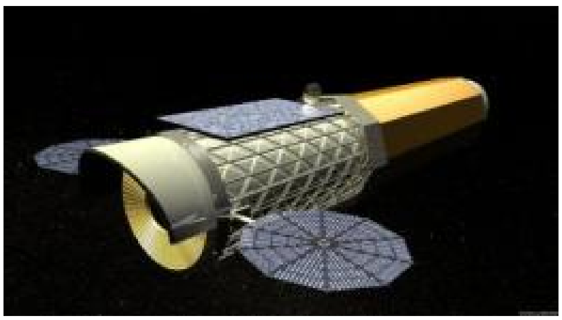

Study of the planned X-ray telescope IXO. Credit: NASA

It is to become the largest X-ray telescope ever: The International X-Ray Observatory (IXO), which has been planned in a cooperation between NASA, ESA and Japan's Aerospace Exploration Agency JAXA, will be launched into space in 2021 and provide the world with brand new information about black holes and, thus, about the origin of the universe. Its dimensions are gigantic: The surface of the mirror alone, which is to capture, for example, the cosmic X-radiation of black holes, will be 1300 m2 in size. It will consist of commercially available silicon wafers with pores of a few millimetres underneath. The quality of these "hidden" surfaces will be tested at the Physikalisch-Technische Bundesanstalt (PTB) with a monochromatic X-ray pencil beam. The new measuring device has been installed at PTB's synchrotron radiation laboratory at BESSY II in Berlin-Adlershof.

eROSITA will do the preliminary work. The German-Russian experiment under the auspices of the Max Planck Institute for Extraterrestrial Physics will be launched into space in 2013. With the aid of a bundle of seven X-ray telescopes, eROSITA will search the whole sky for a specific kind of black hole: supermassive black holes which developed at the dawn of the universe - probably even before the development of the first stars. Scientists expect that - among other things - approximately three million new black holes will be found with this mission. This will, for the first time, allow a complete overview of the formation and development of supermassive black holes to be given. IXO will then be responsible for their systematic investigation. In addition, the new space telescope is to provide much new information about neutron stars and stellar black holes, the second type of black hole which develops when especially massive stars explode. Due to the fact that such a venture is extremely expensive, in 2008 the space agencies of the USA, of Europe and Japan decided to realize this joint project from then on instead of three individual solutions.

IXO can capture the X-radiation of very distant black holes, because this kind of radiation penetrates - in an unhindered way - cosmic dust, which is the most frequently occurring impediment on the way. For that purpose, the mirror in the telescope must be very large, but at the same time light enough. IXO will have one single mirror with a collection surface of approx. 3 m^2, a focal length of 20 m and an angular resolution of less than 5 arc seconds. Due to the required grazing radiation incidence, the whole surface of the mirror must be approx. 1300 m^2. To construct this large surface in a stable and, at the same time, light way, the underneath of commercially available, highly polished silicon wafers will be provided with ribs to allow the wafers to be stacked in rigid blocks. Through this, pores with a cross-section of approximately 1 mm^2 are formed in which the radiation is reflected at the surface of the respective lower wafer. With respect to tangent errors and roughness, the quality of these "hidden" surfaces cannot be investigated as usual from above, but must be determined in the intended application geometry with X-ray reflection at grazing incident angles of approx. 1°. To investigate the reflecting surface of single pores, an X-ray pencil beam is required.

At the "X-ray pencil beam facility" (XPBF) at PTB's synchrotron radiation laboratory at BESSY II, which has recently been extended within the scope of a research cooperation with ESA, a monochromatic pencil beam with a typical diameter of 50 µm and a divergency of less than one arc second is now available for this purpose. It will characterize the X-ray lens systems for IXO at three different photon energies, i.e. at 1 keV, 2.8 keV and 7.6 keV. The lens systems can be adjusted or turned with a hexapod in vacuum with reproducibilities of 2 µm or below 1", respectively. The direct beam and the reflected beam are registered with a spatial resolving detector based on CCD at a distance of 5 m or 20 m from the lens system. For the last-mentioned distance, which corresponds to the intended focal length of IXO, a vertical movement of the CCD detector by more than 2 m has been implemented. First test measurements at this distance were already performed in May 2010, complete commissioning of the extended XPBF is planned for the beginning of November 2010.

More information: Krumrey, M.; Cibik, L.; Müller, P.; Bavdaz, M.; Wille, E.; Ackermann, M.; Collon, M. J.: X-ray pencil beam facility for optics characterization. Proc. SPIE 7732, 77324O (2010)

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