Chinese Scientists Unveil Plans to Build Next-generation X-ray Observatory

By XIN Ling (Staff Reporter)

An artist's rendering of the proposed X-ray Timing and Polarimetry mission. (Institute of High Energy Physics, Chinese Academy of Sciences)

Scientists from the Institute of Physics (IHEP), Chinese Academy of Sciences announced on March 2 that they are going to take the lead in building a next-generation X-ray observatory to explore the "extreme universe". With joint efforts from countries including Italy, Germany, France and the UK, the enhanced X-ray Timing and Polarimetry mission (eXTP), which is estimated to cost over three billion yuan, will be launched in the mid 2020s to push the boundaries of contemporary physics.

Cosmic Laboratory

It has long been scientists' dream to use the cosmos as a natural laboratory for experiments not possible on the Earth. X-rays makes a perfect tool: they are born under conditions of extreme density, gravity, and magnetism, and can be readily used to study the state of matter and see if physics laws still hold in such "boundaries states". From general relativity theory to quantum electrodynamics, the precise measurement of key parameters of X-rays will enable us to confirm or challenge existing theories.

"eXTP will focus on three types of compact objects in the universe – black holes, neutron stars and quark stars", said ZHANG Shuangnan, an astrophysicist from IHEP who has been heading the probe's background study for ten years, at a kickoff meeting in Beijing on March 2, 2018. By measuring the change of light and electromagnetic fields in and around these objects over time, scientists expect to answer important questions like "how exactly do black holes spin?" and "what is the equation of state of neutron stars?"

Using both focusing and collimating technologies, eXTP will study the details of these X-ray sources in the energy range 0.5-30 keV. It will be carrying four different types of detectors: the Spectroscopic Focusing Array (SFA), the Polarimetry Focusing Array (PFA), the Large Area Detector (LAD), and the Wide Field Monitor (WFM).

As a next-generation observatory, eXTP excels in large collecting area which is crucial for precision measurement. According to ZHANG, its focusing array has an area 3.5 times that of ESA's XMM-Newton. Besides a total collecting area as large as 4.5 m^2, eXTP is also able to measure the polarimetry of the sources, a difficult task which was not realized until very recently but helps collect key information about the various asymmetries at or near the surface of black holes and neutron stars.

Paul Ray, an astrophysicist at the US Naval Research Laboratory in Washington DC, noted that recent advances in solid-state X-ray detector technologies have facilitated mission concepts such as eXTP. His group is working on the design of a similar mission, called STROBE-X, which also features large collecting area and wide sky coverage and is waiting to be approved by the 2020 Decadal Survey. "Missions like eXTP and STROBE-X will be critical in the era of time domain astronomy, and will be an essential complement to optical, radio, and multi-messenger studies of the most dynamic and energetic processes in the cosmos," Ray told *BCAS*.

"Our goal is to fly a truly large, flagship mission for astrophysics in the next decade," said Andrea Santangelo, eXTP's international coordinator from the Institute for Astronomy and Astrophysics, University of Tubingen in Germany.

Chinese Leadership

Santangelo believed that "eXTP will be an example of large technical and engineering collaboration mission between Europe and China under the leadership of China."

eXTP is going to be the most expensive space science satellite China has ever developed. Its current budget is roughly three billion yuan, ZHANG said, three times the cost of an average Chinese space science mission like the Hard X-ray Modulation Telescope (HXMT), which was launched in June 2017 also with ZHANG as the principal investigator.

Among the three billion yuan, about two billion will be coming from China, with one billion worth of in-kind contribution from the European members and ESA. As for the work division, the SFA and PFA arrays will be mainly developed in China, LAD in Italy, and WFM in Spain and Denmark.

China is a late comer in X-ray astronomy and space science. HXMT, the country's first and only X-ray satellite which adopts collimation and modulation technology rather than focusing X-ray mirrors, was sent into orbit last June and now taking first data. Before 2015, China did not have a single satellite in orbit dedicated to space-based fundamental research. However, with strong government support in recent

The kickoff meeting of the X-ray Timing and Polarimetry mission was held at the National Space Science Center, Chinese Academy of Sciences on March 2, 2018. (Photo by XIN Ling)

years, they are catching up quickly, putting into orbit a series of small but productive missions such as DAMPE (the Dark Matter Particle Explorer) and QUESS (Quantum Experiments at Space Scale).

The idea of an X-ray timing and polarimetry observatory (XTP) was proposed for the first time in China in 2007. Around the same time, a similar notion called the Large Observatory For X-ray Timing (LOFT) was brought up in Europe. After ESA selected the Advanced Telescope for High ENergy Astrophysics (ATHENA) as Europe's next large mission in the X-ray domain, the LOFT team started interacting with Chinese colleagues, and finally came to what is known today as eXTP. The science goals of eXTP are "highly complementary" to ATHENA, ZHANG said. ATHENA, aiming at mapping hot gas structures, determining their physical properties and searching for supermassive black holes, is slated to launch around the year 2028.

Opportunities and Challenges

At the kickoff meeting, officials from the Chinese Academy of Sciences showed passion and high expectation for eXTP. "Let's make it China's flagship science satellite," said CAS Vice President XIANGLI Bin.

But XIANGLI was very cautious about the planned launch time. "We only have seven years to go. Sounds like a mission impossible," he warned, "but we will coordinate international efforts and deliver it on time."

Santangelo was optimistic. He saw no major technical problem for eXTP to overcome. "The mission's technical readiness is really high," he told *BCAS*. "And I'm not really worried about the timeframe. China has shown its ability to keep the schedule," he added.

By far, there are more than 20 countries and over 100 organizations from around the world participating in the eXTP consortium, including teams from the US, Mexico, India, and South Africa.

In the next two years, an extended Phase A study of eXTP will be carried out, during which period the China-Europe cooperation plan on eXTP will be finalized and financed, said ZHANG. Then they will move on to space qualification model development (Phase B/C) in early 2020. If everything goes according to plan, eXTP will be sent into orbit by the CZ-7 (Long March 7) rocket from Wenchang spacecraft launch site in south China by the end of 2025.