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Pulsar Astronomy in China

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Abstract This paper briefly introduces the past, present and future of pulsar studies in China.

Key words: pulsar: general

1 INTRODUCTION

Pulsars were one of the most important discoveries in astronomy in the 1960s. They are generally believed to be rapidly rotating neutron stars, with extremely stable rotation periods, extremely high surface magnetic fields and extreme mass density. The emission beam is probably constrained by the open lines of magnetic field and pulses are detectable when the beam sweeps across the Earth as the star rotates. Many interesting features have been revealed since they were first discovered in 1967. With developing techniques and the improving sensitivity, about 1750 pulsars have been found so far, including more than 130 binary pulsars. These provide extremely good laboratories for many studies including general relativity, plasma physics, interstellar medium and so on.

As a champion of pulsar study, China's role developed from a watcher to enthusiastic participant, changes which reflected changes in the political and economic environments in China. From 1966 to 1976, the Chinese were involved in the Cultural Revolution. Science was not given any emphasis and development was stagnant for about ten years. As a result of that, no publications about pulsars could be found during that time.

The first light in pulsar research came from Qu et al. (1977) at Nanjing University, the first Astronomy Department in China. Further researches were presented by this group in Nanjing University (Wang et al. 1979) and collaborators at China Scientific and Technical University (Fang et al. 1979, 1980). These studies concentrated on the rotational stability of neutron stars and on the pulsar emission mechanism. It is also worth noting that nulling of pulsars was investigated by Wang et al. (1981) at a very early stage. Huang et al. (1985a, 1985b) later investigated magnetic dipole radiation and the $|z|$ distribution with age of pulsars. Peng and colleagues studied the interior structure of neutron stars (Peng 1988, 2004; Peng et al. 2004).

In the end of 1970's another pulsar study group was established at Peking University (PKU) by Prof. Qiao and Prof. Wu (Qiao et al. 1979; Wu et al. 1979). Their work covered both pulsar theory and observational aspects. The great vitality of their studies fostered several pulsar groups and PKU became one of the important pulsar education bases.

Qiao's work concentrates on pulsar emission mechanisms (Qiao et al. 1998, 2001; Xu et al. 2000), in which they developed an inverse Compton scattering model of pulsar emission. They also developed an inner annular gap model for pulsar radiation to explain the gamma-ray and radio emission profiles (Qiao et al. 2004). Prof Wu works on the pulsar emission geometry (Wu et al. 1986, 1995, 1997, 1998). It is important to point out that the 1997 paper of Wu et al. presented the first pulsar observations using an observing facility in China, the 25-m radio telescope operated by Urumqi Observatory of NAOC.

Pulsar polarization studies initiated with observations at the Parkes 64-m radio telescope in Australia have been very productive (Wu et al. 1993; Qiao et al. 1995; Manchester et al. 1998; Manchester & Han

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2004). In a series of papers, Han et al. (1999, 2002, 2006) have used pulsar rotation measures to investigate Galactic magnetic fields. Results of circular polarization of integrated profiles are presented by Han et al. (1998) and You & Han (2006).

What is the nature of pulsars? This question seems to be diluted with time and most people take it for granted that pulsars are neutron stars. However, a bare strange star model was proposed by Xu from Peking University, and the evidence was investigated including binding energy, thermal featureless spectrum, etc. (Xu et al. 1999, 2002, 2003).

In 1996, Urumqi Observatory made the first test pulsar observation. A timing system was proposed and this became a successful project. This system uses a $2 \times 128 \times 2.5$ MHz filterbank/digitizer, and the receiver band width is 320 MHz. Thanks to Hong Kong University who provided the first support to the project, it was soon recommended and supported by the Key Radio Laboratory in 1997 with the collaboration including the Australia Telescope National Facility (ATNF) and Jodrell Bank Observatory.

Before 2002 July, the receiver was a room temperature system. A cryogenic receiver was build later at ATNF which improved the system sensitivity significantly (see Wang et al. 2001a). Glitches were detected in young pulsars (Wang et al. 2001b; Zou et al. 2004). Scintillation studies are presented by Wang et al. (2005). Long-term monitoring also revealed results in a proper motion study (Zou et al. 2005). Lower frequency observations also produced some good results and were published by Esamdin et al. (2000, 2004). A digital filterbank is now planned, this will greatly improve the pulsar observing capability at Urumqi. High precision pulsar timing and polarization study will be the main goals.

This paper is not able to give a complete report to the Chinese achievements in pulsar astronomy, especially in the high energy area. However, the progress in radio pulsar studies in China demonstrates that the Knowledge Innovation Program in CAS has been productive and has greatly enhanced the science and technical development in the last 7 years. Benefiting from this, the future for pulsar studies in China is optimistic. Through the Chang'E Project, two new larger telescopes have been built: a 50-m telescope in Miyun and a 40-m telescope in Kunming. Pulsar observing systems for these two telescopes were proposed, and they should be available in about two years. Another exciting development is the FAST telescope; pulsar studies are one of its key science goals and this has great potential.

To obtain high sensitivity and large sky-coverage capability, a new 80-m radio telescope in Xinjiang has been proposed. High precision pulsar timing is one of the key projects, as well as using pulsars as probes to detect gravitational waves and study the interstellar medium. It will also be possible to set up a new "pulsar" time standard using the millisecond pulsar timing observations.

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