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Editorial

We are delighted to present this compilation of articles brought together on the special occasion of the 75th birthyear of Prof. G. Srinivasan, a leading luminary of compact star research in India. After an early career in condensed matter physics Prof. Srinivasan, 'Srini' to his friends and colleagues, joined the Raman Research Institute in 1976 and was initiated into compact star research. Since then he has made many pioneering and seminal contributions in this area as well as trained, mentored and inspired many students. His activities have, in a large measure, been responsible for shaping the course of compact star research in India.

He was the first to realize and report in a publication with Ed van den Heuvel the importance of the Eddington limit on luminosity in limiting the accretion-driven spin-up of a neutron star. Today this is widely referred to as the 'spin-up line'. He, along with V. Radhakrishnan, predicted a whole population of spun-up pulsars and named them 'recycled' pulsars—a label that has remained popular in the community. In a statistical study a few years later, Srini and colleagues were able to quantify the size of this population.

One of the landmark discoveries in 1982 was that of the first millisecond pulsar. Although this pulsar did not have a binary companion, Radhakrishnan and Srinivasan quickly realized that it owed its origin to recycling and, based on the spin-up line, predicted its magnetic field strength to be four orders of magnitude below that of the general pulsar population, which was confirmed by later observations. Two more millisecond pulsars, which did have binary companions, were then discovered in quick succession—initiating another important thread of activity in Srini's research group.

All the millisecond pulsars had low magnetic field strengths, as required for spin-up to such short periods. It was thought at that time that old neutron stars would lose their magnetic field strength due to Ohmic decay. Srini and his colleagues realized that the existence of these millisecond pulsars implied that the field decay had to stop for these objects. Thus the concept of residual field was born. Over the years, closer scrutiny has linked all significant field decay in neutron stars to the accretion process itself. Srini and colleagues proposed an elegant physical mechanism for the reduction of interior field of a neutron star—via an interaction between superfluid neutron vortices and quantized fluxoids threading superconducting protons. This has inspired many follow-up investigations in the literature.

In addition to the binary evolution and interior physics, he was also keenly interested in the high energy emission from pulsars and the interaction of pulsars with their surroundings. Based on magnetospheric emission mechanisms, he predicted that millisecond pulsars may be strong emitters of gamma rays, even though till then they had been seen only in radio bands. The launch of the Fermi satellite dramatically confirmed his prediction; millisecond pulsars now constitute one of the most prolific classes of gamma ray sources.

Srini and colleagues also worked extensively on the interaction of pulsar winds with the surrounding supernova remnant, and modelled in detail the evolution of Crab-like supernova remnants. Their work led to the surprising conclusion that the majority of pulsars start their active life as relatively slow rotators, not spinning near break-up period as had usually been thought.

Apart from his scientific contributions to neutron star physics, many of which are referred to in several articles in this issue of *J. Astrophys. Astr.*, he made several important contributions to the growth of Astronomy in India. In 1981, Srini started the biannual Neighbourhood Astronomy Meetings (NAMs) of the astronomers in Bangalore which comprised of people from the Raman Research Institute (RRI, Bangalore), the Indian Institute of Astrophysics (IIA, Bangalore) and the Radio Astronomy Centre (RAC, Ooty). It has been his belief that such interactions between neighbours is an important ingredient to keep the level of research activity high. Many successful NAMs were held at RRI and IIA in the subsequent years.

A year later, in 1982, the highly acclaimed Joint Astronomy Program (JAP) started. The idea for this unique graduate program, combining the strengths of a number of research institutes situated at different parts of the country was conceived by Srini in collaboration with colleagues from RRI, IIA and the Indian Institute of Science (IISc, Bangalore). This initiative was very important coming at a time when none of these places could have been able to sustain an astrophysics graduate program due to the small number of astrophysics faculty available. JAP draws its faculty from the participating institutes and the students selected for this program, after completing the first year of course work, have the choice to carry out their research in any of the participating institutes. Apart from RRI, IIA and IISc, Tata Institute of Fundamental Research and Indian Space Research Organisation also joined this program in the subsequent years. This has been a very successful program and continues to run even today. Not surprisingly, he is extremely passionate about teaching and it has been an integral part of his life. Naturally JAP has benefited from many years of Srini's excellent teaching.

In the 80's, there used to be (and continues to be) very little astronomy and astrophysics at the undergraduate levels. Srini started organizing annual summer schools in astronomy and astrophysics, as a means to introduce the recent excitements in the field to young students who would come from all over the country to attend these schools. Many of those who attended these schools later took up astronomy as a career and went on to become world-famous astronomers. Some of them remember, even to this date, the impact these summer schools had on them.

Most in the Indian astronomical community are also aware of his enormous contributions to the Astronomical Society of India (ASI). He was the President of ASI during 2001–2003. He has also been very actively associated with the International Astronomical Union (IAU) and was the President of Commission 44 on high energy astrophysics during 1997–2000, as well as of Division XI on space and high energy astrophysics during 2000–2003.

He has always believed that the astronomical community of India should have its own journal and is one of the persons responsible for starting *J. Astrophys. Astr.* which is published by the Indian Academy of Sciences (now jointly with Springer). He has published many of his papers in this journal and has always encouraged the youngsters to do so. Till date, he has been the longest serving editor of this journal and ran it quite successfully for a decade during the period 1992–2002.

He has always had a very close association with the Indian Academy of Sciences. He was elected to be a Fellow in 1984 and has served in the Council during 1986–2003. He has been the Secretary during 1986–1988, the Editor of Publications during 1989–94 and the Treasurer during 1995–2003. He has also been instrumental in bringing out a decadal vision for astronomy on behalf of the Academy.

He was awarded the Jawaharlal Nehru Fellowship for 2007–08, which he has utilized to author two introductory astrophysics textbooks titled "What are the Stars?" and "Can Stars find peace?". In these, he brings in his insights and rich experience in teaching to explain astrophysical concepts in a simple and elegant fashion. Not surprisingly, these books are on their way to become astrophysics 'must reads' at the undergraduate level.

Neutron stars, the compact stellar remnants of core-collapse supernovae, are some of the most exotic objects to be encountered in the universe. They provide unique cosmic laboratories for exploring both novel phases of matter as well as extreme physics, impossible to access in terrestrial conditions. This particular area of astrophysics, therefore, challenges our understanding of almost every branch of known physics. It has been our aim to bring out this flavour of neutron star physics in this volume honouring Srini, as well as provide an update on the problems that he himself worked on. We were pleasantly surprised when specialists, from Srini's long-term associates to bright young experts, agreed to devote their valuable time to be a part of this project. Here is a brief summary of the areas covered by these articles.

The composition and the nature of the material inside a neutron star continue to motivate a lot of current research. Recent discovery of a number of massive ($M \geq 2M_{\odot}$) neutron stars has given rise to an intense debate on the composition (in particular, the question of the presence of exotic phases) and consequent equation of state of the interior material, a discussion of which can be found in the first article of this issue. On the other hand, the occurrence of superfluidity in neutron stars and its effect on the observable properties have been long-standing problems of the field. A couple of articles review our current understanding of this area of research. In the early 90s, Srini and his collaborators proposed a simple yet elegant explanation for the reduction of the magnetic field of a neutron star residing in an X-ray binary via the coupling of the quantized vortex lines of the neutron superfluid with the quantized flux lines of the proton superconductor. The current status of this idea has also been discussed.

Srini made fundamental contributions to our understanding of the formation and evolution of neutron stars in binary systems, much of which have been confirmed by the discovery of the double radio pulsar system PSR J0737-3039AB in 2003. In particular, the model for the formation of millisecond pulsars, put forward independently by Radhakrishnan and Srinivasan (1982), Alpar *et al.* (1982) and Fabian *et al.* (1983), has since become the 'standard model' for the formation of these objects, confirmed by the observation of a large number of accreting millisecond X-ray pulsars in recent years, first discovered in 1998. Naturally, the evolution of magnetic fields in neutron stars has been an important ingredient in defining such evolutionary pathways. Discussions on the theoretical models of field evolution in accreting, as well as isolated neutron stars bring us up to date with the current status of this area. The evolution of the magnetic field, in its turn, depends upon the thermal evolution of a neutron star. A review sheds light on the cooling behaviour of the core and the crustal region of accretion-heated neutron stars.

In recent years, with the advent of advanced high-energy instruments, X-ray studies of binary neutron stars have made spectacular progress. Studies of the process of accretion onto high magnetic field neutron stars provide excellent opportunities to understand the evolution of such binary systems. The relativistic iron $K\alpha$ spectral emission line, first detected in 2007, has opened up exciting new ways for probing the strong gravity and dense matter providing another means of constraining the equation of state of the neutron star matter. On the other hand, cyclotron lines from being the only direct estimator of the magnetic field strength, have now become a tracer of the accretion geometry. It is only appropriate that this issue contains an article describing India's AstroSat mission which is a powerful space based observatory for compact star research in the X-ray and UV band.

A study of the pulsar magnetosphere is of crucial importance since it is the key to understanding how energy outflow of a neutron star is produced. Yet, the emission mechanism in the magnetosphere is as much a topic of debate now as it had been in the early days. A possible model for the emission mechanism using charged solitons has been discussed in this context. Reviews of the magneto-rotational and Taylor instabilities, as well as the well-documented but not-yet-completely understood phenomena of nulling, mode-changing and drifting sub-pulses have also been presented. An important issue for the study of neutron stars is the precise measurement of their distances and velocities. A new look at this suggests a description of the velocity distribution by two Gaussians instead of one.

Last but not the least, it is important for a volume like this to mention two related objects, namely the fast radio bursts (FRBs) and gamma-ray bursts (GRBs). The study of these transients (both in radio and in high energy bands) is of great current attention. Two reviews consider these two subjects discussing their general properties, progenitor models and their potential as cosmological tools.

A modern day compendium on neutrons star physics is incomplete without a mention of gravitational waves. Attention has been focused on neutron stars both as emitters of gravitational waves, as well as detectors (via millisecond pulsar timing arrays) of them. The final two articles concentrate on these issues and discuss the importance of neutron stars as tools for probing this newest frontiers of physics.

Neutron star astrophysics started with the 1967 discovery of a radio pulsar by Hewish et al. As we celebrate the 50th year of that discovery and the 75th birth year of Srini, it is only appropriate that Indian Academy of Sciences is bringing out a special issue of *J. Astrophys. Astr.* on a topic close to his heart as a salute to his many contributions to Indian and International science.

Finally, it is our pleasant task to acknowledge the help we have received from a large number of people, without which this task could never be completed. We are extremely thankful to the Chief Editor of *J. Astrophys. Astr.*, Prof. Ram Sagar, who has been very enthusiastic about our idea of bringing out a special issue to honour Srini; and to the Editorial Board for readily endorsing the proposal. We would also like to take this opportunity to express our heartfelt gratitude to all the contributors for enthusiastically agreeing to write for this issue despite their other commitments. Last but not the least, we greatly appreciate the work of Shubhankar Biswas for providing the cover art within a very short time; and the editorial team at the Indian Academy of Sciences for their invaluable help in bringing out this issue.

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