Preface

When the existence of neutron stars was confirmed by the discovery of radio pulsars in August 1967, there was general optimism that it should not be too difficult to explore and understand the physical properties of a rotating magnetised compact star with $\sim$10 km radius. Forty years and more than 13 PhD student-generations later, everybody involved in the $\gg$neutron star business$\ll$ has lost this illusion, meanwhile learning how complex neutron stars are and how difficult it is to understand their physical properties.

Neutron stars form in supernova explosions and/or by an accretion induced collapse of a white dwarf. At the time of their discovery – and for many years later – it was generally accepted that neutron stars can only be observed as pulsars. According to the source of energy they were split into two classes, i.e. being powered by either rotation or accretion. Today, the neutron star world is much more intrincate than it was fourty decades ago. In addition to the accretion powered pulsars, which are predominantly bright X-ray sources, and the rotation-powered pulsars which are observed throughout the electromagnetic spectrum, there are now X-ray Dim Isolated Neutron Stars (XDINs), "radio-quiet neutron stars", Compact Central Objects (CCOs) in supernova remnants, Soft Gamma-ray Repeaters (SGRs) and Anomalous X-ray Pulsars (AXPs).

Accordingly, neutron stars manifest themselves in many different ways. They become visible by high-energy processes occurring on their surface or surrounding region. In most of these objects, ultra-strong magnetic fields are a crucial element in the radio, optical, X-ray and gamma-ray emission processes which dominate the observed spectrum.

Observationally, neutron star research is advancing steadily. A great array of space instruments (the Hubble Space Telescope, ROSAT, ASCA, BeppoSAX, RXTE and the Compton Gamma-Ray Observatory), launched in the last decade of the twentieth century have opened new windows on neutron star research with high quality data in energy bands from the optical to gamma-rays. With the more recently launched satellite X-ray observatories Chandra and XMM-Newton, the H.E.S.S. Array of Imaging Atmospheric Cherenkov Telescopes, upgraded radio observatories and ground based optical telescopes a number of questions which remained unanswered for many years could be addressed and have led to new and exciting findings which have changed the earlier picture of neutron star evolution substantially.

However, even in view of these great observational capabilities and the intense research over a period of more than 40 years, there are fundamental questions which still have not been answered. How are the different manifestations of neutron stars related to each other? What are the physical parameters which differentiate AXPs/SGRs/CCOs/XDINs and rotation-powered pulsars? What is the maximal upper bound for the neutron star mass and what is the range of possible neutron star radii? Is there any exotic matter in neutron stars? Do strange stars exist? And what are the physical processes responsible for the pulsars' broad band emission observed from the infrared to the gamma-ray band? These are just a few of the long standing open questions.

To adequately address these questions, it requires a wide range of scientific disciplines, including nuclear and condensed matter physics of very dense matter in neutron star interiors, plasma physics and quantum electrodynamics of the magnetospheres, relativistic magnetohydrodynamics of electron-positron pulsar winds interacting with some ambient medium. Not to forget the role of a test bed neutron stars provide for general relativity theories as well as being sources of gravitational waves. It is this variety of disciplines which, among others, makes the neutron star research so fascinating and attractive, not only for those who have been working in the field for many years but also for students and young scientists.

Especially students and young scientists often have the problem of finding a comprehensive reference with up-to-date information on multi-wavelength studies from neutron stars and pulsars and the various theoretical models. We have created this book to give them a reference at hand, which not only reviews the progress made since the early days of pulsar astronomy but focuses especially on questions such as (1) what have we learned about the subject and how did we learn it? (2) what are the most important open questions in this area? And (3) what new tools, telescopes, observations, calculations are needed to answer these questions?

Many of the authors who have contributed to this book have devoted a significant part of their scientific career on exploring the nature of neutron stars and understanding pulsars. Every one of us has paid special attention to write an educational comprehensive review article keeping beginners, students and young scientists as potential readers in mind. I am confident that this book will be a valuable source of information for them.

I am very thankful to all the authors for their contributions and to the referees for the time they have spent in getting the quality of the book to its final level.

Garching, *Werner Becker*
July 2008

http://www.springer.com/978-3-540-76964-4

Neutron Stars and Pulsars
Becker, W. (Ed.)
2009, XV, 697 p., Hardcover
ISBN: 978-3-540-76964-4