Introduction

Plasma physics, called by some as the 'queen of classical physics', is a young and vigorous field which continues to make enormous strides in its basic aspects and applications. As a paradigm for systems far from thermodynamic equilibrium, which are dominated by nonlinear collective phenomena, plasmas have no parallel. They are giving us a wealth of experimental information on nonlinear phenomena like chaos, turbulence, anomalous transport, solitons, vortices, etc. and leading us towards quantitative descriptions of such effects and providing an intuition for new guiding principles necessary for describing far from equilibrium systems. At the same time as we learn more about plasmas and how to manipulate them, we have been able to use them in a great number of applications from fusion to free electron lasers, plasma processing to novel accelerators and radiation sources, MHD power generation to interpretation of space and astrophysical phenomena and so on.

Plasma research in India received a shot in the arm when a major activity in this field was initiated at the Physical Research Laboratory, Ahmedabad, in 1982. This activity culminated in the Department of Science and Technology, Govt. of India setting up the Institute for Plasma Research, Gandhinagar, in October 1986. The major objectives of this Institute are to carry out experimental and theoretical research in plasma sciences with emphasis on the physics of magnetically confined thermonuclear plasmas and certain aspects of nonlinear phenomena. In this special section some of the main research and development activities being carried out at IPR are highlighted. It should be emphasized that interesting plasma research is also being done at a number of other places in the country such as Bhabha Atomic Research Centre, Bombay; Centre for Advanced Technology, Indore; Saha Institute of Nuclear Physics, Calcutta; Indian Institute of Technology, Delhi; Rajasthan University, Jaipur, and a number of other university departments, etc.: a summary of this work may be found elsewhere and we shall not be discussing these here.

One of the major technical accomplishments of IPR scientists and engineers has been the design, fabrication, erection and commissioning of the first indigenously built Indian tokamak, christened ADITYA. ADITYA is a medium-sized research tokamak in which plasma current filaments carrying ~ 1/4 mega-ampere can be set up in external fields up to 1.5 T giving fusion grade plasmas of temperatures up to 5 million degrees. The machine was commissioned in September 1989 and has been routinely operated since then and novel experiments on edge turbulence in tokamaks have been carried out. These experiments have already led to entirely new and fascinating discoveries such as first observations on intermittency in edge plasma turbulence, first indication of an inward plasma transport mediated by long wavelength component of turbulent fluctuations being driven by ionization phenomena, etc. These studies have important implications for the world-wide quest for ideal fusion reactors. The article by Sen and Saxena (**page 25**) gives a brief sketch of the technological systems associated with ADITYA and then summarizes the highlights of the physics research programmes. To get an idea about the pace of fusion research world-wide and the issues which determine this pace, we have reproduced (**page 20**) the text of 1992 Artsimovich Memorial Lecture given by P. K. Kaw at the International Conference for Plasma Physics and Controlled Fusion organized by the International Atomic Energy Agency at Wurzburg, Germany (1992). Towards the end of this lecture, one notes the observation that India and other developing nations like China, Brazil, etc. may have to go it alone, if the developed countries (which are quite comfortable in energy) decide that there is no urgency and they can indefinitely delay the development of this technology.

IPR has a major experimental, theoretical and computational effort in problems related to fundamental plasma physics. A summary of the research highlights of the past few years is presented in the article by Kaw (**page 36**). As understandable, the major emphasis is on exploration of nonlinear, collective phenomena, physics of chaos and turbulence and modelling and simulation of fundamental plasma processes taking place in fusion systems. In the last couple of years, IPR has invested some effort in research and development related to plasma processing applications for industries. This is a multi-billion dollar industry world-wide and has been estimated to be worth several tens of crores per year in India at the present time. The article by P. I. John summarizes (**page 48**) the potential of this field in India — what has already been achieved and where one ought to be going.

So, as one comes to the end, one may wonder — what does one learn by the study of plasma science? Well, it promises us the wonders of tamed starfire — the inexhaustible thermonuclear power reactor. It urges us towards development of new technologies — both from the long term fusion point of view and for the more immediate direct industrial applications like plasma processing systems. But above all it gives us the excitement of exploring a new area of physics, rich in non-equilibrium and collective nonlinear phenomena, where one is still groping for guiding principles and important discoveries are yet to be made. It is hoped that the brief overview of the activities at IPR will whet the appetite of the scientific community in India and we will see more of you at the Institute and get an opportunity to interact with you on topics of mutual interest.