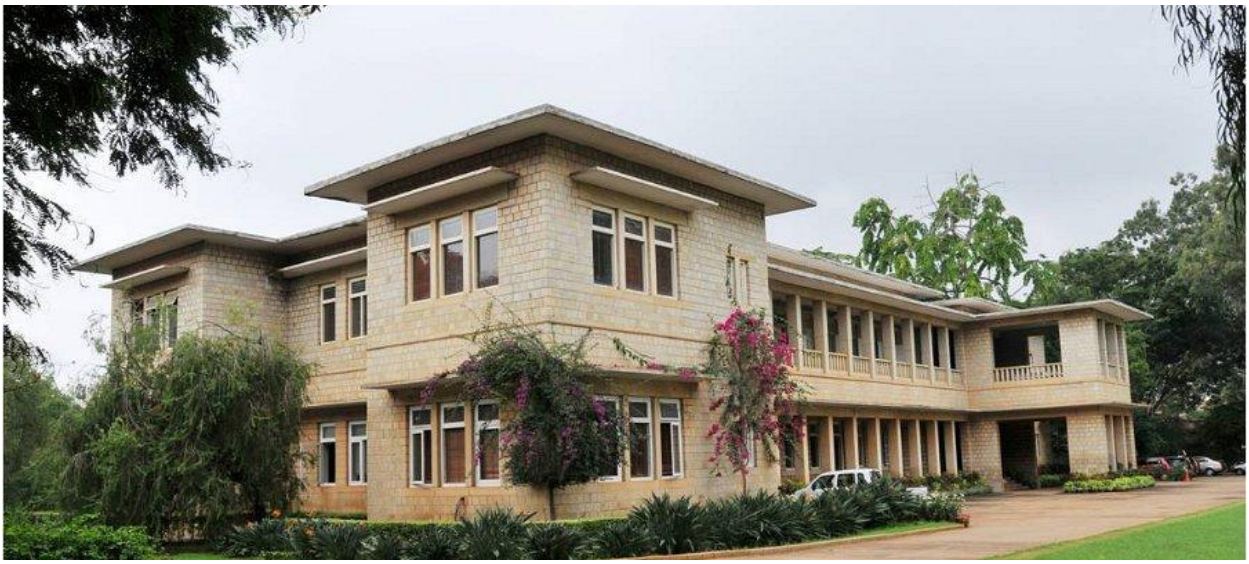
Raman Research Institute
Bengaluru

The Raman Research Institute (RRI), Bengaluru is a pioneering institute pursuing research in basic sciences founded by Indian physicist and Nobel laureate Sir C. V. Raman. He started RRI to carry forward his research soon after his retirement from the Indian Institute of Science in 1948. This self-funded Institute became an autonomous research institute in 1972 and started receiving grants from Department of Science and Technology, Government of India, after the demise of its founder.



Science and Technology minister Dr Harsh Vardhan says: " Founded by Indian physicist and Nobel laureate Sir C. V. Raman, Raman Research Institute Bengaluru is emphasising research work in astronomy and astrophysics, light and matter physics, soft condensed matter and theoretical physics. Its graduate programmes have a good potential to attract young brains and produce future scientists for the nation".

In the last four decades, since RRI became an autonomous DST funded research Institute in 1972, eight RRI scientists have received Shanti Swarup Bhatnagar Prize for Science and Technology. There are couple of scientists who have received Swarnajayanthi Fellowships for their meritorious work. Padma Shree award from Government of India has been conferred on two scientists.

Today, the thrust areas of research at the Institute are 1) Astronomy & Astrophysics, 2) Light & Matter Physics, 3) Soft Condensed Matter and 4) Theoretical Physics. The research activities include work in Chemistry, Liquid Crystals, Physics in Biology, and Signal Processing, Imaging & Instrumentation. RRI, a medium sized research institute has graduate program leading to Doctoral degree in these areas of basic science.

An overview:

1. Astronomy and Astrophysics:

There are broadly three aspects to the research of the Astronomy & Astrophysics group at RRI

(a) Theoretical Astrophysics that involves development of analytical models and computational numerical simulations describing the dynamics, physical properties and underlying phenomena in celestial objects like stars, planets, galaxies, interstellar medium etc. Theorists also work on answering fundamental questions on the formation and evolution of the Universe, a branch of astrophysics called cosmology.

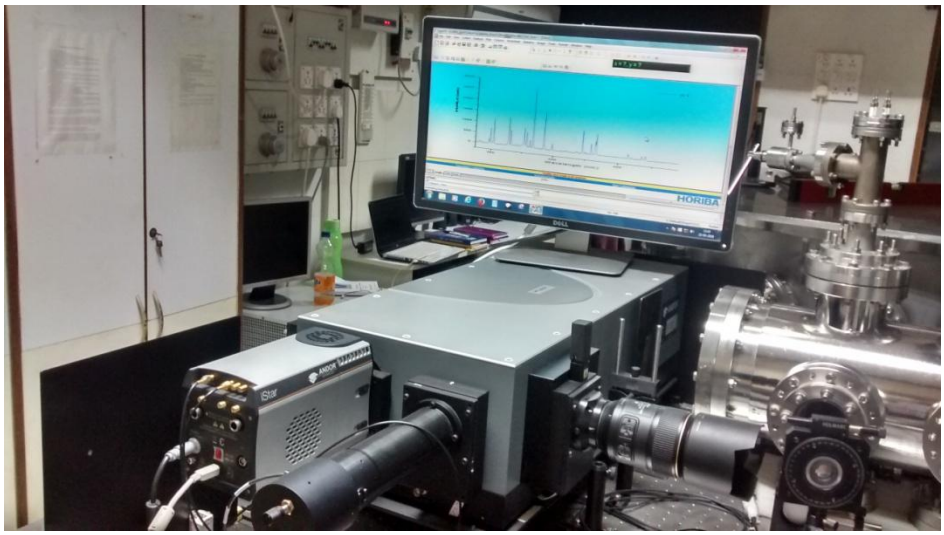
(b) Observational astronomers on the other hand use telescopes built across the globe to study radiation from space across the entire electromagnetic spectrum – low frequency (long wavelength) radio waves to very high frequency (short wavelength and highly energetic) gamma rays. These observations test existing theoretical models and also give rise to new questions that call for answers.

(c) The third aspect involves the design, construction and operation of telescopes, which are often built for very specific purposes, and are strategically located around the world and in space.

2. Light and Matter Physics

Members of the Light and Matter Physics (LAMP) group at RRI are pursuing research in an area of light-matter interaction which is a combination of Atomic, Molecular and Optical (AMO) physics on one hand, and intense laser produced plasmas on the other. Light-matter interactions are being investigated by this group in both classical and quantum domains using experiments as well as numerical and theoretical analysis. The interactions are studied at very high plasma temperatures, room temperature, and at extremely low temperatures attained through laser cooling methods. The use of light from the highest energy densities to the single photon regime allows an impressive range of energy scales to be investigated.

The research of the LAMP group stresses on demonstration of quantum logic using ultra-cold atoms loaded in optical lattices and various nano-traps, investigation of transport and localization properties of light in various random media, ultrafast laser induced plasmas from solid targets, nonlinear optical properties of nanomaterials, laser cooling and trapping of atoms, cold collisions, ion trapping, atoms in cavities, response of cooled atoms to external fields, quantum optics with neutral atoms and non-classical light sources, quantum walk of light, manufacture of single photon sources based on spontaneous parametric down-conversion and their applications to fundamental tests of quantum mechanics, quantum information and computing and quantum communication, quantum simulation of condensed matter physics using degenerate gases, and precision measurements. Currently, quantum logical gates are being designed by tailoring the internal degrees of freedom of quantum optical tools in external potentials.



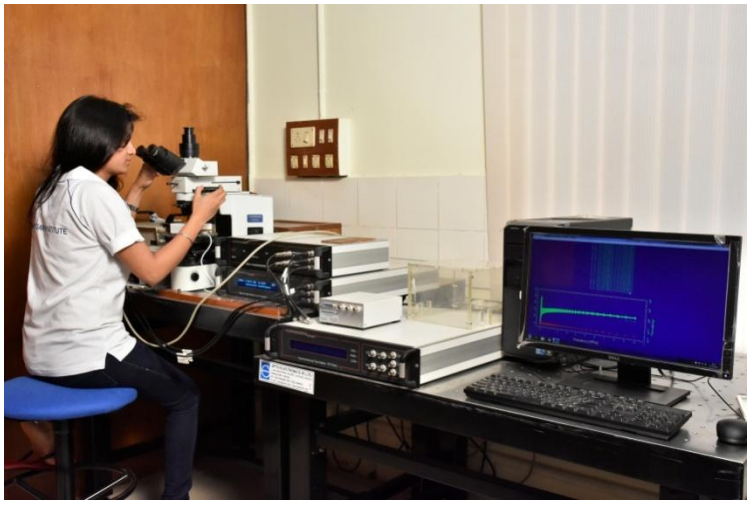
The newly acquired ICCD spectrometer from Andor Technology Ltd, UK, has augmented the laser plasma measurement capabilities of the lab

3. Soft condensed matter

In recent years, soft condensed matter physics or "soft" physics has emerged as a field of research in its own right within the broader field of condensed matter physics. Soft materials, constituted by macromolecules that are held together by weak inter-macromolecular forces, are characterized by complex structures and phase behaviours. Colloidal suspensions and emulsions such as milk and paint, polymeric and biological materials, foam and liquid crystals are some common examples. The sizes of the macromolecules that constitute these materials are typically between a few nanometers and a few micrometers. In contrast to atomic systems whose relaxation times are of the order of picoseconds, soft materials relax on time scales that usually lie between 10^{-8} and 10^{3} seconds, which gives rise to long-lived metastable states. The structure and dynamics of these materials can therefore be easily studied using relatively simple laboratory techniques. Usually characterized by elastic constants that are many decades lower than those of traditional atomic solids, soft materials are viscoelastic and easily deformable and can be used in the study of a variety of non-equilibrium phenomena. Their properties are determined not only by their response to external forces but also by thermal fluctuations. The ease with which inter-constituent interactions can be modified in soft materials ensures that newer materials with interesting and useful properties can also be engineered from them. Their structural complexity, symmetries and mechanical flexibility make soft materials ideal model systems for applications as well as tests of ideas from statistical physics and condensed matter theory.

Chemistry Lab

Microscopy and Dielectric Spectroscopy Lab



The soft condensed matter group at RRI is engaged in research on colloids, polymers, nano-composites, amphiphilic systems, synthesis, characterization and physical studies of liquid crystals and other exciting new areas such as biological physics.

4. Theoretical Physics

The major areas of research pursued by the Theoretical Physics (TP) group are statistical physics, including non-equilibrium statistical physics, biophysics, soft condensed matter and quantum many-body physics, quantum gravity, general relativity and foundations of quantum mechanics. The TP group, by the very nature of its work, often interfaces and collaborates with experimental groups within RRI such as the Light and Matter Physics group, especially in the areas of foundational questions in quantum physics, and the Soft Condensed Matter group, in

areas such as biophysics and non-equilibrium statistical physics. There are also collaborations with experimentalists working in these areas outside the institute.

Research Facilities:

Research Facilities of the Institute are composed of five sections – Electronics Engineering Group, Soft Condensed Matter Group Labs, Mechanical Engineering Section, Library and Computer Section. These are staffed by domain experts in specialized engineering, computing, laboratory instrumentation, test and measurement apparatus and library science. These sections are aimed at enabling the research, including theoretical, computing, observational and experimental. The domain experts are a mix of scientific and technical staff, who participate in research projects as part of research teams as well as provide specialized knowledge and information services to the various research projects undertaken in the Institute.

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