on the Orissa coast lies in empowering the artisanal fishing community and helping them regain their livelihoods and mobilizing them for the conservation of turtles.

2. We would also like to clarify the positive role played by DRDO in the conservation of the Olive Ridleys. DRDO's missile testing range is on an island adjacent to the major nesting beach (Nasi 2) at Gahirmatha. Over the past three years, DRDO has been meticulous in keeping their lights off during the turtle season. They have also extended assistance to WII researchers working in the area, who have their base on Long Wheeler island, which belongs to DRDO. DRDO has also cooperated by postponing their missile tests until after the turtle nesting season. Further, DRDO's ban on any unauthorized entry into a 6 km radius area around their missile testing range on Outer Wheeler Island would be extremely useful in keeping trawlers away from the breeding congregation. Other organizations (such as Jayashree Chemicals Ltd, Ganjam, near Rushikulya beach) have also cooperated by switching off their lights during the nesting season. It is by cooperation with organizations and individuals who work and live along the coast that we can find a solution for sea turtle conservation.

In conclusion, the occurrence of mass nesting of Olive Ridleys at Gahirmatha in March 1999 was a relief for turtle conservationists. However, turtle mortalities continued to be high despite the efforts of conservation groups and the Forest Department. The various agencies working for the conservation of turtles in Orissa should learn from mistakes of 1999 and work towards ensuring that mortality is substantially reduced in the years to come and ensure that offshore breeding waters and the mass nesting beaches get some measure of permanent protection in the future, particularly during October to May.

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Probing fundamental problems with lasers and cold atoms: An Indo-French workshop

The study of the fundamental building blocks of nature is at a turning point. The standard model of particle physics, while highly successful, is destined to undergo several modifications and refinements in the coming decades. Apart from a strong indication from neutrino physics, there are several foundational aspects, including compatibility with gravity, which need to be addressed. The experimental clues required to make progress in this field are expected mainly from three fronts. (a) accelerator-based experiments, which can address some of the issues directly, such as determination of particle mass spectra and direct detection of new particles; (b) cosmology and astrophysics; there are indirect deductions concerning important issues in particle physics (e.g. neutrino physics, unification physics etc.) derived from various astrophysical phenomena coupled with observations on the evolution of the Universe; and (c) high-precision, low-energy, laboratory experiments on a small scale, without the use of accelerators. These non-accelerator particle physics (NAPP) experiments probe particle physics aspects at very low energies, with great precision, to be able to make important statements about phenomena at high energies.

These high precision experiments are driven by novel ideas connecting up the world of high energies to that of very low energies by recognizing phenomena that necessarily involve low energy consequences of high-energy phenomena. Classic examples are proton decay as a consequence of grand unification physics and parity violation in atoms as a consequence of weak interaction between electrons and nucleus.

Significant Indian contributions in NAPP-based experiments were made during the golden era of cosmic ray research. In fact, it is this effort which later laid the foundations for the current accelerator-based research by Indian physicists at international accelerator facilities. Observational high-energy astrophysics is now limited to gamma-ray observations and some air shower experiments. The potential inherent in NAPP experiments in the laboratory to probe fundamental issues which may not be even possible to be addressed using accelerators is yet to be widely recognized and practiced in Indian laboratories.

Recent advances in precision measurements in atomic systems, laser cooling and trapping of atoms, trapping of single ions in electromagnetic traps, atomic interferometry, quantum photon interferometry, ultrasensitive torsion balances, low temperature detectors, etc. are expected to contribute significantly to studies in aspects of particle physics in the next decade. With this in mind, and with a view to starting new activities in non-accelerator physics with tools from atomic physics, optics and other techniques, a discussion meeting was organized in Bangalore by R. Cowsik in 1992. Subsequently a major international conference (ICNAPP 94) was also held in 1994 at the Indian Institute of Astrophysics (IIA) in Bangalore.

During the IX plan, the idea of a centre or laboratory for NAPP activity gained momentum, and the need for a nodal laboratory where research and training could be carried out in this fertile field has been generally welcomed by many senior physicists. One of the planned responsibilities of such a laboratory was to bring together physicists from India and the rest of the world for discussing frontier areas, which have substantial potential to probe fundamental problems in physics. An Indo-French workshop on 'Probing fundamental problems with lasers and cold atoms' was organized to catalyse the necessary awareness and interactions in one of the most active areas of current physics research, namely laser manipulation, cooling and trapping of atoms and ions. The workshop attracted a large number of participants from India and France and has been recognized as the pioneering meeting which brought together a large number of physicists interested in these fields.

The workshop was sponsored by the Indo-French Centre for Promotion of Advanced Research. Several institutions in Bangalore helped in its organization. The French government and embassy provided necessary support and encouragement to enable the participation of Nobel-Laureate Cohen-Tannoudji in the workshop. Inaugurated on 3 January 1999 by B. V. Sreekantan, who has made important contributions in cosmic ray-based particle physics research, the workshop held at the library hall of IIA, continued at a hectic pace with large number of lectures, discussions, and interactions till 9 January.

The study of atoms, of light and their mutual interactions has been among the most productive and influential areas of modern physical research. Apart from being the source for fundamental theories like quantum mechanics, it has served as an effective testing ground for physical theories through possibilities for high precision measurements as well. The development of lasers and the quest for ultra-high precision spectroscopy resulted in developments starting in the mid-seventies culminating in recent spectacular achievements in manipulating atoms with laser light.

Many of these fundamental studies and applications benefit from freezing the natural thermal motion of gaseous atoms. Tremendous progress has been made in achieving this goal over the past two decades or so, exploiting the fact that laser light could be used to manipulate atomic motion. Laser light can be employed to stop a moving atom, or to push an atom in a desired direction. Resulting slow beams, fountains and dense clouds of atoms serve as convenient physical systems where ultra-high precision measurements could be made. Atoms bathed in a multitude of laser beams can get trapped at the intersection of the beams forming a dense, ultra-cold (nearly zero motion) cloud of gas. This cloud can be manipulated in various ways to further freeze out motion of individual atoms leading to spectacular physical phenomena like the Bose–Einstein condensation.

A beam of atoms can be focussed on to a fine spot by pushing with light, and this has become an important tool for high-resolution lithography. The possibilities of using ultra-cold atoms are enormous and applications span from precision measurements of physical quantities and fundamental constants to biology and medicine.

It is also possible to trap a single-charged atom (an ion) and then freeze its motion using laser light. Cold atoms and ions also serve as ideal systems of atomic clocks of unprecedented precision exceeding a part in 10^{17}.

Some of the pioneering ideas which led to these remarkable developments in the last two decades were conceived and elaborated by French physicists, under the leadership of Claude Cohen-Tannoudji who was awarded the Nobel Prize in 1997. Michèle Leduc, the present director of the Laboratoire Kastler Brossel (LKB), Ecole Normale Supérieure, Paris where many of these discoveries were made, and Ramanath Cowsik, who has been actively advocating the need for a new era of NAPP activity in the country, were the major motivating force behind the organization of the workshop, with a clear idea to foster collaborative research in this important area.

IIA has plans to probe the fundamental issues like parity and time reversal symmetry in particle physics and the nature of electromagnetic vacuum, in its laboratories in the near future. There are other institutes like IISc, and RRI in Bangalore, BARC, Mumbai, CAT, Indore, and NPL, Delhi where laser cooling experiments have been started with goals ranging from observation of Bose–Einstein condensation to realization of high precision atomic clocks. The expertise on laser cooling of atoms and ions is only starting to get developed in India. However there exists a rich research tradition in modern optics and laser physics. Therefore it was gratifying to bring together about 130 physicists from all parts of India, representing all the major institutions interested in modern atomic physics and optics for this week-long workshop.

The scientific sessions started with an overview lecture by R. Cowsik on the paradigm of non-accelerator particle physics in which he outlined the see-saw-like connections between high energy phenomena and low energy probes. Martial Ducloy of the University of Paris Nord gave an introductory lecture on Doppler-free spectroscopy, a subject that motivated some of the most remarkable developments in laser cooling techniques. This was followed by a more specific lecture on Doppler-free spectroscopy of alkali atoms, and in particular of sodium by K. K. Sharma (IIT, Kanpur). Cohen-Tannoudji's lecture on subrecoil laser cooling and Levy statistics opened the fascinating world of laser cooling and its techniques. The pioneer was the maestro and also the teacher.

Claude Boccara (ESPCI, Paris) lectured on the VIRGO gravity wave project, especially on the amazingly tight optical tolerances required to achieve the goals and on methods to realize and measure these, F. Vedel on trapping and cooling of ions, including single ions for applications like ultrastable atomic clocks, Bhanu P. Das (IIA, Bangalore) and Philippe Jacquier (LKB, Paris) on violations of the fundamental discrete symmetries, especially parity violation and related effects in atomic systems. Parity violation experiments are of special interest to Indian physicists working in this area since there are two projects starting to probe violations of discrete symmetries in atomic systems. Also, there is a body of leading theoretical work on parity violation, anapole moment and the electric dipole moment in atomic systems by the group of Bhanu Das at IIA. Angom Dileep Singh represented this group and gave a talk on calculations of EDM and on some new experiments on EDM employing laser-cooled ytterbium atoms. Philippe

Jacquier also talked in detail about the ongoing experiment on parity violation pioneered and pursued by Helene Bouchiat – the mother of parity violation experiments in atoms – at the Kastler Brossel laboratory. The experiment uses a pump probe scheme and amplification of the weak signal employing stimulated emission. Pierre Glorieux (Université de Lille) talked about chaotic dynamics applied to lasers, cavities and coupled laser systems. He outlined how experiments using relatively cheap semiconductor and fibre lasers have revealed many interesting aspects of dynamics of light in cavities, which are of importance in applications. Fabien Bretenaker (Université de Rennes) talked about laser physics at Rennes, and gave a detailed account of research on the fundamental linewidth of lasers in non-Hermitian cavity configurations. Alain Aspect gave a fascinating lecture on interaction of cold atoms with evanescent light fields and its applications to the study of short-range interactions like the Van der Waals forces. Martial Ducloy reviewed the extensive work done at the University of Paris Nord on the study of modification of optical properties of atoms interacting with light near dielectric surfaces. The phenomena studied include Mie resonances of dielectric spheres and giant atom-dielectric forces with possibilities leading to atom trapping.

Nonlinear optics has a strong base in India, both in experiments and in theory. K. Rustagi (CAT, Indore) reviewed collective effects in nonlinear optical response and G. S. Agarwal (PRL, Ahmedabad) presented an overview on coherent control of resonant nonlinear optical processes. Rupamanjari Ghosh (JNU, Delhi) discussed methods of generating non-classical states of light and their properties in a unified approach. R. R. Puri (BARC, Mumbai) and N. Nayak (SNBCBS, Calcutta) described their work on micromasers, an important tool in experimental nonlinear optics and atomic physics especially in issues involving interaction of small number of photons with single atoms in ultra-high finesse cavities. S. Dutta Gupta (University of Hyderabad) talked of microspheres as cavities sustaining whispering gallery modes of very high Q values. Such cavities have become an important tool for probing issues concerning cavity quantum electrodynamics.

Interaction of intense laser fields with matter is an emerging field of experimental research in India and an Indo-French workshop on this topic is being planned by practitioners of this field here. G. Ravindra Kumar (TIFR, Mumbai) reviewed the topic and described several experiments in which intense light fields exceeding terra watts of power modify atomic behaviour beyond levels not accessible by the perturbation approach. One can foresee emergence of new physics when such light fields are directed on single trapped ions or on ultra-cold atoms.

Precision atomic clocks are approaching the stability shown by pulsar clocks and the next generation technology involves ultra-cold clouds of atoms like cesium in zero gravity environment in a spacecraft or space station. The first effort in this direction, which is more or less tested and perfected in the laboratory, is called PHARAO, an experiment involving many French groups. Noël Dimarq (Université Paris-Sud, Orsay) described the compact, space compatible design and its implementation, and also discussed applications of cold atoms for the measurement of time, and gravitational and inertial accelerations.

Bose–Einstein condensation in dilute atomic gases and its applications were in focus in many talks. Coherent Josephson tunneling between coupled BEC clouds was discussed by Srikanth Raghavan (University of Rochester) and Subhasis Sinha (IMSc, Chennai) discussed collective excitations in the BEC. Marc Olivier Mews (LKB, Paris) described the experimental techniques involved in achieving BEC, highlighting the example of alkali atoms.

Laser cooling of atoms and ions is perfected to a stage whence these systems are employed in many experiments to probe foundational aspects, especially of quantum physics. The gedanken era has been converted to an era of realizable experiments through these advances, and naturally there were many talks on foundational aspects of quantum physics, spiced up by the presence and active participation of Alain Aspect (Institut d'Optique, Orsay). N. D. Hari Dass (IMSc, Chennai) talked about possibilities of using trapped ions for tests of quantum gravity and for testing the controversial concept of protective measurements. S. M. Roy (TIFR, Mumbai) discussed a causal quantum theory which is more realistic than the de Broglie–Bohm theory. The new theory has experimentally testable predictions, which could be accessible with the new technology involving cold atoms and light. Anu Venugopalan (PRL, Ahmedabad) talked about how mesoscopic superpositions evolve into classical-like states through decoherence with an example involving atoms in cavities. Apoorva Patel (IISc, Bangalore) gave an overview of the emerging field of quantum computation where advances in trapped ion technology are playing a major role.

The Indian ambitions in the area of laser cooling and trapping were represented by several institutions including BARC, IISc, RRI, NPL, CAT and IIA. S. A. Ahmed, B. N. Jagtap and Pushpa Rao (BARC, Mumbai) outlined the research planned by BARC in the areas of laser cooling of neutral atoms and trapping and cooling of ions. Vasant Natarajan of IISc, Bangalore talked about an important application of laser cooled atoms – lithography. Santa Chawla (NPL, Delhi) described the NPL programme for building high stability atomic clocks employing laser-cooled cesium atoms. With possibilities of Indo-French collaboration, this important programme of high precision metrology is sure to gain considerable momentum if sufficient funds become available.

There were several talks on ongoing experiments in the frontier areas of laser cooling and trapping. One of the exciting talks was on the attempt to trap and cool fermionic atoms (^{6}Li) to obtain a degenerate fermionic gas of weakly interacting atoms in a trap. Marc Oliver Mewes described the motivations and also the experiments in progress at the Kastler Brossel Laboratory.

Michèle Leduc and Unnikrishnan (TIFR, Mumbai and IIA, Bangalore) described the experiments at ENS, Paris on laser cooling and trapping of helium 4, and indicated the future goals including laser cooling of helium 3, study of cold atom collisions and possibility of Bose–Einstein condensation in helium 4.

One of the major attractions of the workshop was the three public lectures by the visiting French physicists, all of whom have made pioneering contributions. Claude Cohen-Tannoudji talked about manipulation of atoms by light at the NIAS auditorium, in the Academy Lecture organized by the Indian Academy of Sciences. He was welcomed and introduced as the latest Honorary fellow of the Academy. A day later, the auditorium at RRI overflowed with enthusiastic students and scientists to listen to the inimitable Alain Aspect talking about his famous experiments on the EPR problem and Bell's inequality. The third public lecture was given by Michele Leduc at IIA on an important development in medical imaging of lungs and cavities, a technological breakthrough from her group's extensive research on helium 3. The magnetic resonance imaging technique employing optically spin polarized helium 3 could be a major tool in diagnosis and treatment of lung diseases.

The afternoon on the last day of the workshop was dedicated to a discussion on future collaborative research between Indian and French laboratories. P. G. S. Mony, Director, IFCPAR outlined the procedure for proposing collaborative programmes and offered cooperation and support. Several definite proposals were discussed, and these are expected to be followed up this year. In the coming years several fruitful collaborations between the French and Indian scientists are expected to come up, which would fulfil the goals of the present workshop.

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RESEARCH NEWS

Curious or dubious: The story of a hydrocarbon with an exceptionally short C=C bond length

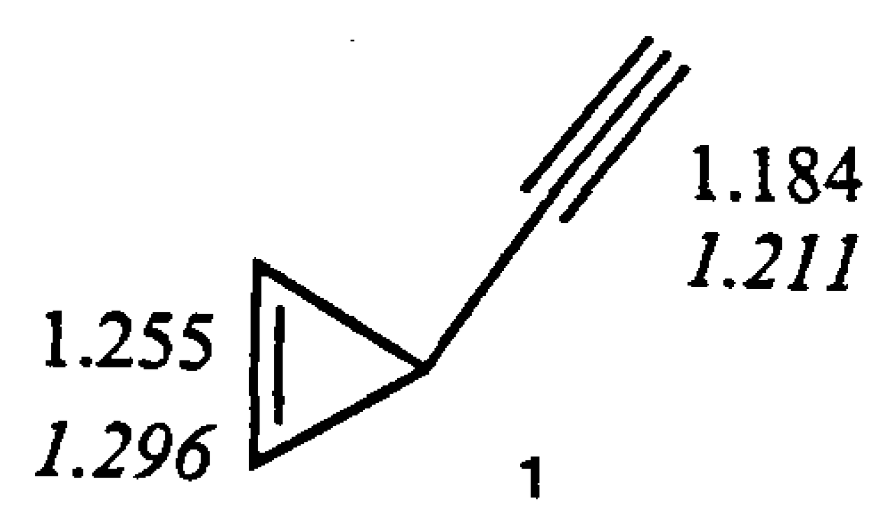
J. Chandrasekhar

One of the greatest achievements in molecular sciences this century has been the accurate determination of structures of a large number of chemical systems. While a variety of spectroscopic and diffraction methods have been used successfully for this purpose, X-ray crystallography has led the way. For the vast majority of chemists, single crystal X-ray structure determination represents the ultimate unimpeachable evidence for the proposed structure. The geometric details obtained through crystallography have also served as the basis for our present understanding of structural chemistry. These data represent an important source of parameterization as well as benchmarks for empirical theoretical models. The quality of quantum chemical procedures, which often use drastic approximations while solving the Schrödinger equation, has also been judged through comparisons of structural predictions with X-ray results.

Interestingly, in recent years, the roles seem to have been reversed. The accuracy of quantum chemical calculations is getting better all the time. And X-ray structure determination is not always devoid of problems, a fact well recognized by the best of professional crystallographers[1]. It is now being suggested that artifacts in experiment may perhaps be identified through comparisons with computational studies. Not a pleasing prospect to many. A recent as yet unresolved controversy provides an example of arguments we may expect between cutting edge theory and experiment.

One always hopes to find something interesting with small ring systems and the rather innocuous hydrocarbon 3-ethynylcyclopropene (**1**) amply fulfills the expectations. The X-ray structure determined at 120 K by Baldridge *et al.*[2] revealed an unusual feature. While all the geometrical parameters were typical of the subunits present in the molecule, the double bond length in the ring was found to be exceptionally short. In fact, the value of 1.255 Å represents the shortest formal double bond ever measured crystallographically in a hydrocarbon.

Acceptor groups are known to reduce the remote bond length in cyclopropyl units, with many examples known from different types of experiments[3]. The elegant analysis of Hoffmann invoking the cyclopropane Walsh orbitals in inducing this structural distortion is textbook material in qualitative MO theory[4]. Even the simplest of theoretical methods reproduce this effect. However, the bond contraction in **1** is of a far greater magnitude. Baldridge *et al.* therefore chose to test what high level *ab initio* theory had to say regarding the C=C length in **1**. Using a variety of



1

theoretical methods ranging from Hartree-Fock to correlated procedures and also density functional methods in conjunction with large basis sets including polarization functions, the calculated bond length was consistently larger, being in the range 1.27 to 1.30 Å. The authors concluded that the 'deviation could come from difficulties in approximating the orbital arrangement in **1**'.

This disturbing conclusion provoked Schleyer and Schaefer to bring to bear considerable computational power to