# In this issue

## The S. N. Bose centennial

One of the most remarkable scientific papers that came out of India was that by S. N. Bose entitled Planck's Gesetz und Lichtquantenhypothese (*Z. Phys*., 1924, 26, 178). We reproduce an English translation of this paper on **page 943**. Bose was born on 1 January 1894. The story of this paper is very well-known and has been oft repeated. When he had to teach the derivation of Planck's formula to his M Sc students in the Dacca Univerity he found innumerable logical gaps and inconsistencies even in the derivations by the masters – Planck and Einstein. By a stroke of genius, he derived Planck's law in early 1924, without making explicit use of the wave aspects of light quanta, a thing never done before. He made three assumptions (i) light quanta are indistinguishable; (ii) in the case of light quanta the number of particles is not conserved; (iii) each momentum state of a quantum has a two-fold degeneracy. His derivation was simple, logical and could stand the test of time. The story goes that he sent the paper first to the *Philosophical Magazine* where he and Saha had earlier published papers. It is not quite clear whether the paper was rejected. In any case he courageously wrote to Einstein, the man who, at that time, was considered the foremost physicist of the world: 'If you think this paper is worth publication, I shall be grateful if you arrange to publish it in *Zeitschrift fur Physik*.' Einstein considered the paper so important that he translated it and got it published within six weeks of his receiving. He added a translator's note: Bose's derivation is an important step forward. The method given here also gives the quantum theory of an idealized gas as I shall show elsewhere. He applied the Bose statistics to ponderable matter (i.e. when the number of particles is conserved) and thus was born the field of *Bose Condensation*.

We are not reproducing Einstein's classical papers on this subject. However we reproduce a paper by Hanbury Brown and Twiss (**page 945**) which created history in optics. In classical interferometric experiments it is incumbent that the two signals from a single source be combined before detection *so that their relative phases are preserved*. In the new dispensation (intensity interferometry) signals from a source are recorded by two *independent detectors*. The consequence of this is that the relative phases of the two signals would be lost. The intensity of each signal fluctuates because of the different times of arrival of the photons. Now the intensity fluctuations of the two beams are correlated. Hanbury Brown and Twiss showed for the first time that photons in two coherent beams of light are correlated – thus discovering a new type of interferometry. Much controversy raged when this unconventional paper appeared. It was E. M. Purcell (renowned for his Nobel Prize-winning discovery of nuclear magnetic resonance and the discovery of neutral atomic hydrogen in interstellar space through its 21 cm hyperfine line) who convinced the doubting Thomases that intensity interferometry *was really based on Bose statistics* and 'the Brown–Twiss effect, far from requiring a revision of quantum mechanics, is an instructive illustration of its elemenary principles'. This paper is reproduced in this issue (**page 947**) followed by the lecture of Hanbury Brown on '*Bose statistics and the stars*' (**page 950**) and another of a historical nature by N. Mukunda '*Bose statistics – Before and after*' (**page 954**).

S. R.

## Bose and the Nobel Prize

In Sweden, when I sought from the Nobel Foundation and its Secretary information about Raman's Nobel Prize they most graciously gave it to me with the request not to publish it before 1980, i.e. 50 years after Raman received the Nobel Prize. I was also able to get many sidelights of interest. Almost every aspirant (with a few exceptions) canvasses for support; in fact the American Embassy in Stockholm had a 'Nobel desk' whose main task was to follow up and to 'push' the American nominations. In 1929 when the committee found that Raman would be a very strong candidate for 1930 and that he had been nominated by many scientists from different parts of the world excepting from India, they sent discretely a nomination form to the Calcutta University so that this lacuna could be corrected. 'The Calcutta University promptly nominated one D. M. Bose.' I exclaimed 'Not S. N. Bose of the Bose Statistics.' 'No D. M. Bose – who is he?' I explained that D. M. Bose was a respected senior scientist of India who was known for his fostering of physics in Calcutta but his international reputation was nowhere near that of his name sakes S. N. Bose or J. C. Bose. They also informed me that after the war the Nobel Foundation wrote to Raman enquiring whether there was any Indian worthy of nomination to the Nobel Prize. Raman wrote saying he could think of only one whose work although it was a flash in the pan, had influenced quantum mechanics greatly. He also said that they should consult Dirac and Einstein about this matter. I understand that Bose was in fact nominated for the Nobel Prize by Dirac. I could not however verify this as such information is considered confidential.

S R

## Methane budget from paddy fields in India: significance of the study

It has been known for many years that carbon variants along with other radiatively active trace gases, collectively named 'greenhouse gases' (GHG), absorb heat radiated from the earth's surface, while allowing short wave solar radiation to reach unhindered. This leads to a warming of the air near the surface of the earth. Measurements show that concentrations of greenhouse gases in the atmosphere are increasing at an accelerating pace. We have the best records for $CO_2$, which today stands at over 360 ppm, It took the first 70 years of this century for atmospheric $CO_2$ to go up from 300 to 330 ppm. However, in the past 20 years $CO_2$ concentration has increased by another 30 ppm. While most of the problem arises from the high consumption of fossil fuel energy in industrialized countries, a part of the problem also arises from deforestation in tropical regions thereby reducing carbon sinks. The primary responsibility for degrading the global commons however lies with the industrialized nations. The per capita $CO_2$ emissions of USA, for example, are 19 times that of India.

Methane ($CH_4$) is second in importance to $CO_2$, as a greenhouse gas. Methane concentration in the atmosphere was 0.7 ppm in the preindustrial era. Now it is nearly 1.7 ppm by volume. Still it is much lower than the 360 ppm of atmospheric $CO_2$. But one molecule of $CH_4$ traps about 30 times more heat compared to a molecule of $CO_2$.

Concerned with the potential adverse consequences to global climate as a result of continued increase in GHG, a *global framework convention on climate change* was adopted at the UN Conference on Environment and Development held at Rio De Janeiro in June 1992. The convention became operational on 21 March 1994, following the notification of this convention by the requisite number of countries. On 29 December 1993, the global biodiversity convention came into force. This convention is designed to promote the conservation of forests and other ecosystems rich in biological diversity and as such should help to preserve and enlarge carbon sinks.

The convention on climate change specifies, 'Each of the contracting parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emission of greenhouse gases and enhancing its GHG sinks and reservoirs'.

The 'polluter pays principle' has also been incorporated in the convention. Thus, we are obliged to monitor GHG emissions in our country and to initiate steps which can reduce emission and increase sinks. It is in this context the paper, 'Methane budget from paddy fields in India' (page 938) is both timely and important.

The current burden of $CH_4$ in the atmosphere is about 4700 million tons. The annual global emission is estimated to be about 500 million tons of which emissions from rice fields may range from 20 to 100 million tons/year. Although the potential for $CH_4$ release from rice fields has been known since a long time, systematic measurements of $CH_4$ fluxes in rice fields began only in the early 1980s. Methane is released from flooded rice fields to the atmosphere by diffusion, ebullition and through roots and stems of rice plants.

Water regime, temperature, soil properties and rice genotypes are the major factors involved in the production and flux of $CH_4$ in rice fields. Up to 90% of the $CH_4$ produced during a rice growing season may be oxidized in the aerobic rice rhizosphere and flood water-soil interface before it reaches the atmosphere. Unfortunately, current global estimates of $CH_4$ fluxes from rice fields do not take into account varying flood water regimes, especially in rainfed areas where drought spells may reduce considerably emission rates. Neither do they account for organic amendments, release of entrapped $CH_4$ during initial drying phases and ebullition induced by cultural practices, all of which should increase emission rates. This underlines the need for a continuous improvement of measurement techniques. We have the largest area under rice in the world (over 40 million ha), and hence research in this area is essential for enlightened public policy.

Concurrently with efforts in the refinement of measurement tools, we should also develop and spread a mitigation package. Mitigation measures include better water management, increasing water percolation, use of nitrification inhibitors and breeding of rice varieties with low $CH_4$ emission potential. There is need for studies on the impact of mixing neem cake with urea, since neem cake serves as a nitrification inhibitor. Mitigation measures will help to promote the efficiency of rice farming, in addition to minimizing $CH_4$ emission from rice fields.

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