J. C. Bose and the German scientific community: scientific and political context

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The spearhead of Indian science, Jagadish Chandra Bose (1858–1937) was born about 150 years ago. His discovery of the short-wave electromagnetic waves and invention of a number of scientific instruments brought India on the international scene. His scientific work on plant physiology was novel and highly disputed. During his lifetime, Bose interacted intensively with European men of science. To explore his interaction with the German scientific community, documents of the German Ministry of Foreign Affairs, Bose's correspondence with the Swedish Nobel Laureate Svante Arrhenius, Encyclopaedia of Plant Physiology and other German literature have been analysed. The results of the analysis are presented in the present note.

'I have been asked whether the title of the book (*Leben und Werk von Sir Jagadis C. Bose – Life and Work of Sir Jagadis C. Bose*) is really on the groundbreaker of science, who is by chance an Indian, or groundbreaker of the Indian science. I replied: both'. Bose's admirer and biographer Patrick Geddes wrote these words[1]. J. C. Bose (Figure 1), the spearhead of Indian science, was born on 30 November 1858. His first scientific work that brought India on the international scene, was the discovery of short electromagnetic waves[2,3]. A number of biographies deal with various aspects of Bose's life[1,4–7]. It is well known that his scientific work in the field of optics and electricity was accepted by the European scientific community. However, some of his theories on plant physiology were highly disputed. The reaction of the British community was positive[8]. In 1929, in its 30th issue, *The Indian Review* reported that Person (USA) was unable to observe plants pulse, which was reported by Bose. In the middle of 1960s, in the *Handbuch der Pflanzenphysiologie* (*Encyclopedia of Plant Physiology*), it was mentioned that 'Unfortunately Bose's theoretical views and his emotional style of reporting have generated what may be an excessive scepticism concerning the validity of his observations'[9]. In the following paragraphs, it will be shown that Bose's work started appearing in the German literature in the late 1890 and continued for many decades. As we shall see below, the reaction of the German scientific community was always not positive.

Figure 1. J. C. Bose (Courtesy: Bose Institute, Kolkata).

Bose's electromagnetic radiation station – Made in Germany

Between 1895 and 1898, Bose worked on the properties of electromagnetic radiation and published thirteen articles. He devised an instrument to produce electromagnetic waves[7] with wavelength up to ca. 5 mm. The international scientific community came to know about it, when Bose introduced his 'wave apparatus' in Liverpool in September 1896, on the occasion of the 66th Meeting of the British Association for the Advancement of Science. John Murray in the report of the Association stated that the apparatus could be used to verify the laws of reflection, refraction, absorption, interference, double refraction and polarisation. In Germany, a teachers' related journal referred to *Philosophical Magazine* (1897, **43**, 55) and gave details of apparatus[10]. It was modified and marketed by the German instrument-making firm, Max Kohl A G, Chemnitz (Figure 2).

Bose and his German visits

Indo-German relation: In order to understand Bose's visits to Germany and the reaction of the scientific community, it would be worth mentioning about the Indo-German political relation in those days.

Like other imperial powers, Germany was equally interested in colonies. The German newspaper *Vossische Zeitung* dated 24 July 1908 reported: 'We consider the maintenance of British rule in India as great luck not only for British but also for other people including Germany whose import from there amounted to 407 million marks in 1907 and whose exports to that country amounted to 105 million marks'. However, within the German community, there were some people who supported India's freedom struggle against the British colonial power. During the time of the Weimer Republic, the exiled Indian politicians in Germany had won a measure of respect that ensured good relations between India and Germany. In order to spread knowledge about India, on 21 February 1918, the Bund der Freunde Indiens (Union of Friends of India) was founded in Berlin. Some of its prominent German members were Admiral Recke and Hermann von Staden. Meanwhile, Germany had lost the First World War and among the signatures under the Versailles Treaty was that of an Indian. The India-friendly attitude in the Germany of the 1920s later led to the foundation of different Indian-oriented institutions such as Indian Information Bureau – referred to by some historians as 'some kind of unofficial embassy of India in Germany'[11]. Officially the Bureau was meant to give information to Indian students.

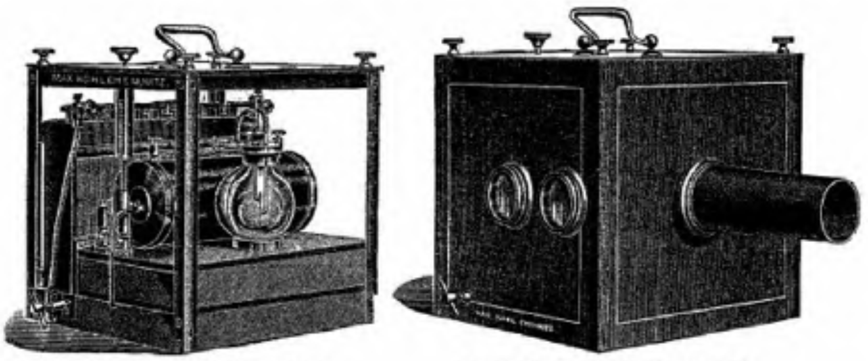

Figure 2. 'Vollständige Sendestation für kurze Wellen (complete primary station for short waves) after J. C. Bose. (Courtesy Max Kohl AG, Chemnitz).

Bose's visits: Under the above-mentioned political situation, Bose interacted with the German community. As we shall see below, in German circles he was seen as an important 'political scientist'. For the first time during 1896–97, Bose visited Germany and lectured at the Physical Institute – University of Kiel[12]. In the fourth volume of *J.C. Poggendorff's Handwörterbuch*, Bose's publications until the year 1900 are listed[13]. Again, in 1914–15, Bose came to Germany and delivered lectures in different universities[12].

In recognition of Bose's researches in 1920, he was elected as a Fellow of the Royal Society of London. From England on 30 August 1920, he wrote a letter to the Swedish Nobel Laureate Savante Arrhenius and expressed his wish to deliver lectures before the Society of Physicians and the Royal Swedish Academy of Sciences. In another letter dated 6 September 1920, Bose sent the titles of his lectures related to plant physiology. Bose, who was extremely happy with his stay in Sweden, on 24 October 1920 thanked Arrhenius for his advise to visit Berlin. Further he wrote: 'Professor Haberlandt who is the greatest living authority in plant-physiology kindly arranged for a meeting of leading scientific men of Germany. You will be pleased to learn that my lecture and demonstration was received with the highest appreciation'.

Bose's visit was successful. He found people who were ready to translate his work. In the Foreword in *Die Physiologie des Saftsteigens*, the translator of Bose's work – Ernst G. Pringsheim – German University in Prague wrote, 'In 1920 during a visit in Berlin Sir J. Ch. Bose wished that I should make his work known in Germany by translation of his next book. I gladly agreed, as I was of the opinion that his work among the German researchers was not well known'[14] (translated from German). Though Pringsheim dissociated from the conclusions of Bose's work, he was of the opinion that 'Hopefully they (results) will not lead only to criticism, but also to the repetition of his (Bose's) experiments, through which my hard work might be recompensed'.

Three years later, Bose's *Plant Autographs and their Revelations*[15] was translated by K. Höfler under the title *Die Pflanzenschrift und ihre Ofenbarungen* and published by Rotapfel Publisher, Zürich[16] in 1928.

Bose and the German Ministry of External Affairs: In 1926, Bose started on his seventh mission to Europe[12]. The German Consulate for British India and the Ceylon colony on 10 December 1925 wrote to the Ministry of External Affairs, Berlin, that according to the press, Bose has been invited by the Committee of Intellectual Co-operation of the League of Nations at Geneva. He tends to go to Europe in the beginning of the next year. In the letter it was also mentioned that Bose was well recognized and supported by the Government. In one of such lectures Bose talked to the German Consulate and spoke warmly about Germany. He expressed his desire to deepen his contacts with the German men of science. Bose wished to have an invitation from the German scientific community (File: R64464, Political Archive of the Foreign Affairs, Berlin).

On 19 January 1926, the Ministry of External Affairs, Berlin wrote a letter to its Embassy in London as is evident from a reply of 26 January 1926. The Ministry of External Affairs, Berlin was interested to know Bose's views about Germany and the Committee of Intellectual Co-operation of the League of Nations. The London office could not give more information than what was sent by its Consul in Calcutta. However, the German Consulate in Geneva in a letter dated 30 January 1926, sent a long report about the planned visit. But it was unable to mention anything about Bose's views on Germany and the League of Nations.

Bose turned down the invitation of the Institute of Plant Physiology, University of Berlin, due to some reasons, as is clear from a letter dated 30 September 1926. The author of the letter wrote to the Prussian Ministry for Science, Art and Public Education that he has heard from Indian scholar Sir J. C. Bose that he could not come to Germany. But next year, he might come and deliver a lecture to the German Botanical Society. This visit never took place. In 1928, Bose came to Munich and delivered a series of lectures[12].

From the foregoing discussion it is evident that in spite of different views about the scientific issues, due to political reasons Germany was interested in establishing contact with Bose. How Bose's scientific work was seen by his colleagues will be discussed in the following.

Bose in German scientific literature

Gerta von Ubish vs Bose's science: One of Bose's critics was Gerta von Ubisch, University of Heidelberg. In *Der Biologe* she wrote:

> 'The theories of Indian Sir Jagadis Chunder are widely known among the laymen educated community, which is delighted by them. However, in experts circles, either they are mostly ignored or laughed at. Here and there, we find the repetition of his experiments, but this literature is not easily available. Now the time has come to say publicly against him, and should be said about Bose's two theories, which are mostly spread, that is, the theories of ascent of sap and growth of plants[17]. (translated from German).'

In the footnote von Ubisch pointed out that she is mainly discussing the two books (both German translations) and the *Transactions of the Bose Institute*, Calcutta (1918, 1–2).

In those days there were two theories on the ascent of sap in plants. According to the physicists, living cells do not play any role. The ascent of sap is due to the transpiration of leaves. The liquid in mesophyll cells of leaves concentrates due to evaporation. An osmotic attraction is thus set up in the leaves. However, the physiologists proposed a vital theory, which was based on the living cells. According to the physiological theory, it was speculated that the living cells were instrumental in producing water movement. Bose was of the opinion that the transport of water is maintained by physiological action, and that it is not the mere presence of living cells, but their rhythmic or pulsating activity, which maintains the ascent of sap[18]. von Ubisch did not go into detailed criticism of Bose's theories, but turned to the drawbacks of the instruments which he had used to measure the growth of plants.

One of the hard and fast rules of natural sciences is reproduction of experimental results. In order to defy observations of the opponent, the best argument is to repeat the experiments and produce different results. The story is trivial if standard instruments are used for experimentation. But if the instruments are self-made, and it is a unique specimen, difficult to be reproduced by others, the issue becomes complicated. von Ubisch was in a dilemma as she mentioned: 'One is unable to re-examine Bose's results, because one cannot make the apparatus: firstly they are very expensive, and secondly, everyone who understands something from apparatus knows, one must say that they will not function differently than in the case of Bose, ... Inexpediently one needs to make other apparatus to test the results[17]. (translated from German).

In fact, she made the apparatus, but it was different from than that of Bose. The reason for the high quality of Bose's instrument is to be found in the Indian culture. In caste-ridden India, there was a forced 'extreme specialization' almost in all professions. About such a system the French writer Jean Baptist Tavernier lamented as follows: 'A goldsmith would not work in silver, nor a silversmith in gold. In the looms, a weaver would weave only one single sort of stuff during the whole life, unless he be compelled to take another in hand'[19]. Bose had the privilege to have such experts. He trained them to make the required instruments, contrary to Germany, where due to industrialization mass production had begun of not only day-to-day life objects, but also scientific instruments. Already in the second half of the 19th century, many Germany firms started supplying standard instruments either for demonstrations or for research purposes.

Bose's adventurous theories vs cold calculation of Westerners: Translation of Bose's work meant recognition of his ideas. Bose's critic von Ubisch questions': how Bose's theories have been established in Germany? She replies herself: 'Because they are adventurous, they inspire fantasies than our cold calculations and sober experiments'. In the end she suggested:

> 'It must be our duty to stop the mixing of exact science research with the nice wonderful fantasies. We want to have fairy tale books and science books; but we don't want that the popular literature becomes a hybrid between the two, even then not, if for the time being it increases interest in the natural sciences[17] (translated from German).'

von Ubisch suggested that if we are not able to hide our sympathy for the metaphysical tendencies of Bose, at least we must reject his methods of research of nature.

And history verdicts – Bose's instruments and scientific ideas after 1950s

Bose's instruments: As far as critics on Bose's instruments were concerned, they were theoretical in nature. In 1961, Ruge, while discussing various types of auxanometers (instruments to measure the growth of plants) wrote that the lever-based instruments are useful as long as the weight arm and force arm ratio does not exceed 1:10. But if 'according to Bose and Das (1918), Bose (1919, 1928, . . .) proposal the ratio is increased to 1 : 100, . . . Under such conditions, the apparatus is so sensitive to vibrations that one cannot imagine to have a laboratory to record the vibrations'[16]. However, Ruge did not forget to mention the positive side of the story, i.e. 'due to Bose's experiments, we were able to construct the best and most exact auxanometers'[16].

Bose's experimental and theoretical work: Karl Umrath[20] while discussing the autonomic movement of leaves and excitation processes, gave due credit to Bose for his work from the years 1907 and 1928. While discussing the phenomenon of transportation in plants, Hermann Fischer referred to Bose's observations[21]. However, the masterpiece seems to be Bose's third book on *Comparative Electro Physiology*, brought out by Longmans, Green and Co., New York in 1907. Though Munk (1876), MacDougal (1896), Magnus (1904) and Montemartini (1907) studied the effect of electricity on plants[21], Bose seems to be the first to study the phenomenon not only in sensitive but also non-sensitive plants like ferns.

The phenomenon of seism reaction, that is, the movement of various parts of a plant due to external reaction has a long history. This was one of the fields where Bose was the master. Many of Bose's results, in particular his 14 figures have been reproduced by later authors[22,23] Another phenomenon which interested Bose was the mechanical irritation like rough contact (friction) and prick or wound, and its effect on the growth of plants. As far back as in the 1880s, Charles Darwin had studied the effect of wound on the roots. In 1918, Bose measured and showed the effect of a needle prick on the growth of plants. In 1959, Bünning[22], while discussing the effect of wound in plants, referred to Bose's work. It clearly shows that Bose's work had its renaissance in the late 1950s. Bose's work from the years 1907 and 1913 on the reaction of plants to electric current[24] was referred to in the German literature[25] in the 1950s. In 1962, Anker, while discussing ortho-geotropism in shoots and coleoptiles, mentioned Bose's observations on the reaction of plants to electricity[26].

Light intensity and its effect on photosynthesis had been studied[27] by plant physiologists as far back as in the 1770s. However, the breakthrough came after proper counting of air-bubbles to understand the difference between apparent (measured by the amount of carbon dioxide taken by plant) and real (after applying correction) photosynthesis. In the former, Bose played an important role. In 1924, he developed a method for careful study of photosynthesis[27]. In 1925, Bose constructed a photosynthetic recorder for measuring the rate and change in the rate of photosynthesis. He reported that with this instrument it is possible to measure a deposit of carbon hydrate as small as a millionth of a gram[28].

In the end it will be worthwhile to mention about Bose's idea of pulsating growth. It found positive acceptance in 1965. Dormer, while discussing self-regulatory phenomena in plant development wrote[9]:

> 'It has been suggested on several occasions that the growth of plant organs does not proceed smoothly but in a sequence of pulses with a periodicity of a few minutes. This idea is particularly associated with the name of Bose (1927) . . . the balance of evidence so far would appear to be in favour of pulsating growth[1].'

The foregoing discussion leaves no doubt that, though at the beginning Bose's ideas were criticized, in the second half of the twentieth century they were accepted and found to be worth mentioning in the *Encyclopaedia of Plant Physiology*. To highlight Bose's 150th birth anniversary, it will be worth quoting Australian biophysicist V. A. Shepherd[29]:

> 'Bose's contention that coupled electrical and mechanical pulsations or oscillations are fundamental to life-processes in plants seems less far-fetched in 1999 than in the decades immediately after his death, when the discovery of chemical signalling through auxin and wide acceptance of the tension–cohesion theory pushed Bose's work to the far fringes of orthodox plant physiology'.

Obviously, the last word has not been said, about Bose's theories on plant physiology.

Conclusion

Scientists are a part and parcel of the political and social system. Bose's example shows that they can be used or misused by politicians for good or evil. Bose was seen as a man to improve Indo-German relations. And vice versa, Bose took advantage of such connections to spread his scientific views in Germany.

Bose's 'adventurous theories', that had no mathematical formalism, appealed to laymen and philosophers. With his instruments, Bose demonstrated the 'death of plants'. Such experiments fascinated the public. This evidently shows the 'power of experiment' over 'cold calculations'.

Bose's example also shows that sometimes scientific works last long until a community is ready to accept particular theories, more so, when they are against the established knowledge. However, it also shows that scientists are ready to revise their ideas.

1. Geddes, P., *Leben und Werk von Sir Jagadis C. Bose*, Rotapfel Verlag, Erlenbach-Zürich und Leipzig, 1930.
2. Ramaseshan, S., *Curr. Sci.*, 1996, **70**, 172–175.
3. Emerson, D. T., *IEEE Trans. Microwave Theory Techn.*, 1997, **45**, 2267–2273.
4. Saha, M. N., Obituary notices of the Fellows of Royal Society London, 1941, **3**, 2–12.
5. Mukhopadhyay, A. K., *Colonialism, Nationalism and Scientism – A Study of Acharya Jagadis Chandra Bose*, K.P. Bagchi and Co, Calcutta, 1995.
6. Nandy, A., *Alternative Science – Creativity and Authenticity in two Indian scientists*, Oxford University Press, New Delhi, 1995, pp. 1–87.
7. Dasgupta, S., *Jagadis Chandra Bose and the Indian response to Western Science*, Oxford University Press, Oxford, 1999.
8. Singh, R., *Nuncius*, 2004, **2**, 713–723.
9. Dormer, K. J., In *Handbuch der Pflanzenphysiologie* (ed. Ruhland, W.), Springer Verlag, Berlin, 1965, vol. XV(1), pp. 485–491.
10. Anon., *Unterricht*, 1897, **3**, 149.
11. Leifer, W., *India and the Germans – 500 years of Indo-German Contacts*, Shakuntala Publishing House, Bombay, 1971, pp. 285–291.
12. Bhattacharyya, P. (ed.), *Acharya J.C. Bose – A Scientist and a Dreamer*, Bose Institute, Calcutta, 1997, vol. 4, p. 464.
13. von Oettingen, A. J. (ed.), *J.C. Poggendorff's Biographisch – Literarisches Handwörterbuch zur Geschichte der Exacten Wissenschaften*, Johann Ambrosius Barth Verlag, Leipzig, 1904, p. 161.
14. Pringsheim, E. G., *Die Physiologie des Saftsteigens* (von Sir Jagadis Chunder Bose), Verlag von Gustav Fischer, Jena, 1925.
15. Bose, J. C., *Plant Autographs and their Revelations*, Longmans, Green and Co., New York, 1927.
16. Ruge, U., In *Handbuch der Pflanzenphysiologie* (ed. Ruhland, W.), Springer Verlag, Berlin, 1961, vol. XIV, pp. 47–70.
17. von Ubisch, G., *Biologe*, 1931–1932, **1**, 83–88.
18. Bose, J. C., *The Physiology of the Ascent of Sap*, Longmans, Green and Co, London, 1923, pp. 1–6.
19. Bag, A. K., *Indian J. Hist. Sci.*, 1982, **17**, 82–90.
20. Umrath, K., In *Handbuch der Pflanzenphysiologie* (ed. Ruhland, W.), Springer Verlag, Berlin, 1962, vol. XVII, pp. 542–561.
21. Fischer, H., In *Handbuch der Pflanzenphysiologie* (ed. Ruhland, W.), Springer Verlag, Berlin, 1958, vol. VI, pp. 925–932.
22. Bünning, E., In *Handbuch der Pflanzenphysiologie* (ed. Ruhland, W.), 1959, vol. XVII, pp. 184–238.
23. Galston, A. W., In *Handbuch der Pflanzenphysiologie* (ed. Ruhland, W.), 1959, vol. XVII, pp. 492–529.
24. Bose, J. C., *Research of Irritability of Plants*, Longmans, Green and Co, New York, 1913, pp. 198–210.
25. Umrath, K., In *Handbuch der Pflanzenphysiologie* (ed. Ruhland, W.), 1959, vol. XVII, pp. 135–147.
26. Anker, L., In *Handbuch der Pflanzenphysiologie* (ed. Ruhland, W.), Springer Verlag, Berlin, 1962, vol. XVII, pp. 103–152.
27. Gabrielsen, E. K., In *Handbuch der Pflanzenphysiologie* (ed. Ruhland, W.), Springer Verlag, Berlin, 1960, vol. V, pp. 27–78.
28. Bose, J. C., *Collected Physical Papers*, Longmann, Green and Co Ltd, London, 1927, pp. 331–337.
29. www.ias.ac.in/currsci/jul10/articles33.htm, dated 28.10.2008

ACKNOWLEDGEMENTS. I thank Prof. Falk Riess and his group, at Physics Education, History/Philosophy of Science, University of Oldenburg, Germany for providing research facilities. Thanks are due to the Royal Swedish Academy of Sciences Archive (Stockholm) for Bose–Arrhenius correspondence, and Political Archive of Foreign Affairs, Berlin for Bose's documents referred to in this note.

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Edited and published by P. Balaram, Current Science Association, Bangalore 560 080.
Typeset by WINTECS Typesetters (Ph: 2332 7311), Bangalore 560 021 and Printed at Lotus Printers, Bangalore (Ph: 2320 9909)