BEQUEST OF PAVLOV TO THE ACADEMIC YOUTH OF HIS COUNTRY

WHAT can I wish to the youth of my country who devote themselves to science?

Firstly, gradualness. About this most important condition of fruitful scientific work I never can speak without emotion. Gradualness, gradualness and gradualness. From the every beginning of your work, school yourselves to severe gradualness in the accumulation of knowledge.

Learn the ABC of science before you try to ascend to its summit. Never begin the subsequent without mastering the preceding. Never attempt to screen an insufficiency of knowledge even by the most audacious surmise and hypothesis. Howsoever this soap-bubble will rejoice your eyes by its play it inevitably will burst and you will have nothing except shame.

School yourselves to demureness and patience. Learn to inure yourselves to drudgery in science. Learn, compare, collect the facts!

Perfect as is the wing of a bird, it never could raise the bird up without resting on air. Facts are the air of a scientist. Without them you never can fly. Without them your "theories" are vain efforts.

But learning, experimenting, observing, try not to stay on the surface of the facts. Do not become the archivists of facts. Try to penetrate to the secret of their occurrence, persistently search for the laws which govern them.

Secondly, modesty. Never think that you already know all. However highly you are appraised, always have the courage to say of yourself—I am ignorant.

Do not allow haughtiness to take you in possession. Due to that you will be obstinate where it is necessary to agree, you will refuse useful advice and friendly help, you will lose the standard of objectiveness.

Thirdly, passion. Remember that science demands from a man all his life. If you had two lives that would be not enough for you. Be passionate in your work and your searchings.

Typed early morning & sent today by post with covering letter

BSM 1/3/71

Sir. C.V. Raman's work on the Dynamics of Vibrations.

by

B. S. Madhavarao

I wish to refer here briefly to some mathematical aspects of the earlier work of Raman related to the theory of vibrations of several types, ~~mainly both simple and coupled and degenerate~~. This work was done during the years 1914 onwards at Calcutta when he was greatly interested in stringed instruments, specially in the subject of Indian musical instruments. It would be interesting to recall in this connection a few remarks made by the late Dr. Ganesh Prasad, a fine mathematician of high calibre in his Presidential Address to the Physico-Mathematics Section of the Indian Association for the Cultivation of Science [Report for 1914, p. 39] viz° Prof. Raman is well-known to you all of you as an experimentalist of world-wide reputation. But some of you will feel surprised to learn that by his recent mathematical researches, he has firmly established his claim to be considered a sound mathematician. The two papers which he read before the Calcutta Mathematical Society during the current year are very valuable, and I trust he will continue his mathematical researches". It is indeed fortunate for Science that Raman did not take Ganesh Prasad's advice to continue research in Mathematics for its own sake, but, like a sound mathematician, decided to use Mathematics to help him explore new physical phenomena ~~to understand problems in Physics which he could intuitively create create by intuition~~ a theory of his own creation!

His contributions to the theory of vibrations have been numerous, and ~~and well known in the lit~~ ~~it is impossible in this short note to describe them all fully. I shall just choose a few which appear (to me) to be of mathematical interest~~. The first one relates to the general investigations [Bulletin No. 6, 1912, Ind. Assoc. Cult. of Science] on the maintenance of vibration of strings, and deals with topics such as the small motion at the nodes of a vibrating string, the amplitude and phase of oscillations maintained by forces of double frequency, the maintenance of compound vibrations by a simple harmonic force, and the vibration curves of oscillations maintained by an inhomogeneous string. The nature of the mathematics employed is the one based on Rayleigh's classical book on the Theory of Sound, which appears to have been was thoroughly mastered and studied by him and become almost his Bible. Plenty of mathematics has been used, but it is always has always been accompanied by experimental details illustrating the mathematical results, and

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and also the different types of maintenance are explained by beautiful figures. As is well-known, the last topic of the investigations relating to the vibrations of an inhomogeneous string is really the Sturm-Liouville eigenvalue problem [Hilbert-Courant, Methoden, 1926, p. 237], and it is interesting to note that Raman has beautifully succeeded in transferring this eigen-value problem for the case of maintenance of vibrations also, by simple physical explanations rather than by use of the difficult mathematical techniques involved. Equally true Such an approach is also evident in his investigations [Bull. No. 11, 1914] on the maintenance of combinational vibrations by two simple harmonic forces, and on by other types of periodic fields.

The most interesting of his researches on the vibration of strings is contained in the comprehensive memoir [Bull. No. 15, 1918, pp. 1–157] on the mathematical theory of the vibrations of bowed strings and of musical instruments of the violin family, with exptl. verification of the results. The necessary dynamical theory is developed using Lagrange's equations of motion, and for simple and forced vibrations, and the notions of normal co-ordinates. A Fourier analysis is made of the types of possible motions, and the difficult question of convergence of the Fourier series is dealt with in a physically intuitive manner, using the just the essential mathematical steps. In view of the complexity of the problem, emphasis is laid upon the cases which are of practical interest in music, and the choice of these cases exhibits clearly his ability to overcome / skip over / avoid mathematical hurdles. This certainly goes to his credit if only we realise that, even with the present day techniques of mathematical physics relating to vibration and eigenvalue problems, the more complex dealt with in this memoir is cannot be solved in full. One of the important ~~grand~~ results in this paper is the quantitative explanation of the effect of a mute on the quality of the violin tone. Another result remarkable result of mathematical interest is his analysis of the nature of the motion when n, the number of discontinuities, is a prime >1, or n is composite. A careful examination of the manner in which this analysis is accomplished shows that he has not used any sophisticated results of prime number theory, but just the definition of a prime number!

Another investigation relating to the vibration of circular membranes is also of great interest. It is well known that percussion instruments, generally speaking, give rise to inharmonic overtones and are thus musically imperfect.

The Indian Mridanga forms a remarkable exception to this rule as found by Raman experimentally. The character of vibrations of the associated heterogeneous membrane which gives rise to these remarkable properties ~~were~~ was investigated by the method of sand figures, and definite results obtained. The problem of the oscillations of heterogeneous membranes is an extremely complicated one, ~~being again~~ being again a general Sturm-Liouville eigen-value problem whose solution depends on ~~that~~ theory of integral equations [Hilbert-Courant, pp. 255 and § 10, p. 273]. It is very ~~remarkable~~ interesting to note that the ~~physical~~ result of physical significance mentioned at the end of Paragraph 2, p. 279 of the above Reference is inherent in Raman's explicit results.

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Lastly a result of rather academic interest is Raman's attempt at a classical derivation of the Compton effect by using the theory of vibrations [Ind. J. Phys. ~~Vol~~ Vol. 3, p. 357] based on the result that even the most arbitrary type of wave-disturbance can be represented as the superposition of plane trains of waves travelling in all directions in space.

~~Although Raman~~ In conclusion I might mention that Raman always evinced a keen interest in topics of mathematics even of the purest type. I remember, when I was a student of the M.Sc. Pure Mathematics classes of the Calcutta University during 1919-21, and he was the ~~renowned~~ Palit Professor of Physics, his finding time to question ~~an young student~~ me (an young student of about 20 years then) as to what I was learning, and ~~listening~~ listen to my talking about topics like Algebra of quantics and Higher Plane Curves! ~~After last meeting Annual meeting~~ He retained this interest in pure mathematics, which he often likened to ~~arts~~ an art like painting ~~and~~ or music, throughout his life. Such men of wide interests and broad vision are rare indeed.

B. S. Madhavarao.

To

MEMBERS OF THE INDIAN SCIENCE CONGRESS

Professor I.P. Pavlov, the great Russian physiologist, died on 27 February 1936 aged 87 years. He was a Foreign Member of the Royal Society and his colleagues in Leningrad, knowing that I was very fond of the great old man and that the Society would be concerned to hear of his death, telephoned the news to me from Leningrad. I wrote to my friend Prof. P. Kupalov, his chief assistant, asking for any information which could be used in preparing an obituary notice.

Kupalov in reply sent me his own translation of a "Bequest" by Pavlov to the young scientists of his country, written just before his death. It applies equally to all of us, old and young alike. I thought that Members of the Indian Science Congress might be glad to have, with my greetings, a copy of Pavlov's words, so simple, so wise and so eloquent of the true spirit of scientific inquiry.

A. V. HILL

Delhi, 1 January 1944.