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A problem in learning Bohr's theory of hydrogen atom

Dileep V. Sathe, Dadawala Jr. College,
1433 Kasba Peth, Pune, MH, 411011, India
dileepsathe@vsnl.net

Every student of science has to learn Bohr's theory of hydrogen atom in the introductory courses of physics and chemistry, particularly. Even students interested in biology also have to learn this theory in the core courses of science. As this theory is known for nearly 90 years, the question is: Can we take for granted that, now, there are no problems in learning of this theory? Sadly, the observations of educationists – made in the last quarter of the 20th century – show that there are some problems in learning this theory because there is a global problem in the learning of circular motion itself. What is that problem? Why is it still persisting? Why is it global in nature? In the present note, author addresses these problems. First let me summarize that difficulty itself.

The Problem: Educationists have observed that when students are asked, in questionnaires, to identify the resultant force, acting on a body performing the uniform circular motion, most of them ignore the centripetal force and choose the tangential force as the resultant force. John Warren reported this observation in1971 and then many educationists from various countries observed the same. So the problem to be addressed by teachers of physics / chemistry, particularly, is: Why do students tend to choose the tangential force and ignore the centripetal, while analyzing the circular motion?

About 20 years ago, I was very much surprised to know this because the circular motion is being taught and learnt for nearly 300 years. More over, the observation is global in nature – not local or regional. Hence I decided to restudy the relevant concepts, topics from the logical point of view. This approach is a unique one, even today, but it could lead me to discuss my work with Prof. Abdus Salam in August 1991 and to dedicate a lecture to his memory in an international symposium on experimental gravitation, in Samarkand, Uzbekistan in August 1999.

My hypothesis: I have shown that the said tendency among students originates in the fact that the present treatment of uniform circular motion **logically conflicts** with other basic concepts like the concept of work. In the concept of work, we teach students to resolve the applied force into sine and cosine components, if it is not along the motion or displacement. More over, we insist on taking the cosine component along the motion and then include it also in the

equation of work. In other words, teachers and educationists have to realize that students' choice of tangential force in the circular motion is logically consistent with our choice of cosine component in the equation of work. As long as this conflict is there, students will continue to ignore the centripetal force and to choose the tangential force. Secondly, there is such conflict between the circular motion and the law of parallelogram forces also. The latter preaches the logic that the motion has to be in the direction of resultant force only but in the circular this does not happen and hence students ignore the centripetal force. My hypothesis also easily leads one to realize why this tendency is global in nature, as the same physics is taught all over the world the ensuing problem is also same every where.

Another logical factor, which motivates students to choose the tangential force, is the fact that we cannot decide the direction of motion, anticlockwise or clockwise, on the basis of centripetal force. This inability has been termed as the Anticlockwise/Clockwise paradox. It has been discussed at several places and with Prof. Abdus Salam also, starting with the first discussion in the ICPE Tokyo Conf. in August 1986. I suggest readers of this journal to try the following activity in their educational institutes.

The Activity: Choose some students of colleges, from physics, chemistry, biology and electronics and try to have same number of students from each department – say 10 students. Divide these 40 students into two groups, A and B, and teach them Bohr's theory of hydrogen atom. For this, draw the anticlockwise orbit of electron on the blackboard in the classroom of group A and draw the clockwise orbit of electron in the other classroom of group B. Then mix these groups and see whether they accept Bohr's first postulate or not and ask them to write their comments. In fact, I would like to know comments of all interested students and teachers.

References:

1 Sathe, Dileep V. (August 1991) The Evaluation of Teaching Uniform Circular Motion, text of my talk in the GIREP Conf., Torun, Poland, see p. 379 of the Proceedings. It contains my original questionnaire.
2 Sathe, Dileep V. (July 1996) The Jupiter comet-collision: some conceptual implications, text of my talk in the IAU Collo., London, England, see p. 150 of the Proceedings. It explains how the overwhelming interest of the public, in the collision of Shoemaker-Levy comet with the Jupiter in July 1994, has greatly increased the necessity of considering my hypothesis earnestly.