



## Marcos Moshinsky



Kiev, Ukraine, 20 Apr. 1921 - Mexico City, Mexico, 1 Apr. 2009

**Nomination** 9 June 1986

**Field** Physics

**Title** Professor at the Universidad Nacional Autónoma de México

**Commemoration** – The impressive biographical data of Marcus Moshinsky is very well documented in the Yearbook that we have in front of us, so I think there's no sense in reading it to you. I think I can do justice to his genius better by telling you my personal recollections on four encounters with his work, which show the breadth of his intellectual horizon. The first was very long ago in 1951. I was in Göttingen and there appeared a paper in *Physics Review* which derived the essential consequences of general relativity just by solving the Schrödinger Equation in an external gravitational potential, and we were very perplexed. It was not talking about the non-Euclidian geometry, and it came from Princeton, where Einstein was still alive and dominating. The paper sort of said that, actually, we don't need Einstein, we can derive all this very simply. We tried to find a mistake, as there were many crazy theories around, but we couldn't find anything so we decided it was correct. Then we didn't know what to do, since he had apparently found an effect which is present, as is the one of general relativity, so perhaps you should add them since both are correct. But if you do that then you get a factor 2 and destroy all the agreement with the experiment, so that's not what you want to do. We saw that this had some philosophical implications, namely you can either look at this situation by saying that space is flat, there's nothing like a curved space, but there's the gravitational potential. However, it changes measuring rods and clocks – in this case it was the hydrogen atom which was pretty good as a measuring rod and as a clock – thus the gravitational potential changes the size of the measuring rod in such a way that you get the illusion that space is curved. On the other hand, you can also look at it the other way and say that measuring the hydrogen atom has never changed, it's always the unit of length by definition, so we have to take it as the definition of the length. It is just that the space is curved and therefore it can be different at different places. So you can say, as it is now said in general relativity, that the gravitational field is an illusion and, in reality, that space is curved. You see that this already has a philosophical flavour. It shows that what is reality may in some cases be undecidable, because there are two points of view looking at it. Since they are mathematically equivalent, you cannot say one is wrong and the other is correct, and yet they say something different about what is reality. So this was one of his works and you will see that the other works that I encountered always touched upon some general principles. The next encounter was when I was working with Goldberg and Gellman on the question, to what extent the requirement that nothing propagates faster than light gives some restraints on the scattering amplitude. We found that, strangely enough, it's the mathematically analytic properties of the scattering amplitude that can say whether something propagates faster than light or not. And then we were informed that these analytic properties could all nicely be found in the work of Wigner and Moshinsky, who at this time was working with Eugene Wigner on nuclear physics. So, again, his work had some influence on general principles. Well, he did many things but the next time we had a complete different approach. It came from the quark model of elementary particles. In the proton you have three quarks, so you have to handle the three-body problem and somehow you have to classify the states of this three-body problem. But it's not just any three-body problem, but they are confined in a potential which doesn't let them go out. The simplest model for a confining potential would be harmonic potential and so it is worthwhile to look at that and, in fact, there you can solve the three-body problem and it was just a sort of heavy task of group theoretic investigations of the properties of the states with respect to the exchange of particles. Then it turned out that this was something that Marcus Moshinsky had done some time ago, and it had implications on what came out of elementary particle physics. In fact, the classification of the states then lead eventually to the notion of colour, that there must

be another quantum number hidden in the quark systems. The fourth system is again something different, it has to do with the Heisenberg commutation relations. They were introduced by Heisenberg but at that time people were mathematically not prepared to make any sense of it. Heisenberg knew nothing about what it would be, but warned and said, well, maybe they are matrices because for matrices the commutative laws of multiplications did not hold. Then people found it couldn't be matrices because, if you take a trace of a commutator it is always zero, so you have a contradiction. Then people said, perhaps they are just abstract operators. However, this didn't help because the operators can be shown as not to be bounded. Unbounded operators lead to a lot of mathematical complications. The best tool in this game is the coherent states that come from these commutation relations. And this is, again, one of the fields where Marcus Moshinsky was very active. In summary, I would say he was a master in all theoretical physics of the 20th century and therefore he was just the man that a country like Mexico needed. Although he was not Mexican by origin, he was born in the Ukraine, I think he became one of the dominant figures of South American theoretical physics altogether and I think it's well deserved that he became almost a cult figure in Mexico.

Walter E. Thirring

### **Most important awards, prizes and academies**

*Awards:* Academia de la Investigaci#n Cient#fica (1961); Fomento Educativo (1966); National Science Prize (1968); Luis Elizondo (1971); Research Prize – Universidad Nacional Aut#noma de Me#xico (1985); Bernardo A. Houssay, Organization of American States (1990); UNESCO Science (1997); Wigner Medal (1998); The Weizmann Award in Science and Humanities (2003). *Academies:* President (1962-63), Academia de la Investigaci#n Cient#fica, Me#xico (1960-); Academia Brasileira de Ciencias (1963); President, Sociedad Mexicana de Fi#sica (1967- 69); El Colegio Nacional, Me#xico (1972); Academia Latinoamericana de Ciencias (1963); Third World Academy of Sciences (1985); Pontifical Academy of Sciences (1986); American Academy of Arts and Sciences. *Honorary Degrees:* Goethe University, Frankfurt, Germany (2000).

### **Summary of scientific research**

After receiving his Ph.D. in Princeton in 1949 working with Wigner on 'Boundary conditions for the description of relativistic interactions', his interest turned to a schematic theory of nuclear reactions with the help of these boundary conditions and the possibility of a time dependent description of the scattering and reaction process. Later he became interested in nuclear structure problems based on the shell model, and in particular ways of simplifying the calculations through the concept of transformation brackets for harmonic oscillator states. This concept became a basic tool in nuclear shell and Hartree-Fock calculations. His interest in harmonic oscillator states led him to try to understand their underlying group structure and thus to the irreducible representations of the unitary groups and their applications, first in 2s-1d shell and later in collective models of the nucleus. This continues to be an interest of his, though at that point through the symplectic Lie algebras related to the microscopic understandings of the collective motions. Along the way he became interested in the representation of canonical transformations in quantum mechanics, particularly when those transformations were non-bijective as it happened in the case of action and angle variables. This gave rise to many publications and was also an interest he continued until his death. A line of research he initiated concerned the structure of matter in strong electric and magnetic fields. He was also concerned with problems of relativistic quantum mechanics through the introduction of a new concept he called sign spin.

### **Main publications**

*Books:* Moshinsky, M., *Tables of Transformation Brackets* (with Brody, T.A.), Gordon and Breach, 1969; Moshinsky, M., *Group Theory and the Many Body Problem*, Gordon and Breach, 1967; Moshinsky, M., *The Harmonic Oscillator in Modern Physics: From Atoms to Quarks*, Gordon and Breach, 1969, Russian trans. by MIR in 1972; Moshinsky, M., *The Harmonic Oscillator in Modern Physics* (with Smirnov, Yu.F.), second enlarged edition, Harwood Academic Publishers (1996). Over 275 *research papers* most of them in international journals. Among the most recent ones: Moshinsky, M., 'Boundary conditions for the description of nuclear reactions and their time dependent behavior', *Phys. Rev.*, 81, p. 347 (1951); 84, pp. 525-33 (1951); 88, p. 625 (1952); Moshinsky, M., 'Transformation brackets for harmonic oscillator functions', *Nuclear Physics*, 13, p. 104 (1959); Moshinsky, M., 'Group Theory of Harmonic Oscillators', *Nuclear Physics*, 18, p. 697 (1960); 23, p. 177 (1961) in collaboration with V. Bargmann; Moshinsky, M., 'Basis for irreducible representations of unitary groups and some applications', *J. Math. Phys.*, 4, p. 1128 (1963); 6, p. 682, p. 1540 (1985); 7, p. 691 (1966); 10, p. 455 (1969); Moshinsky, M., 'Canonical transformations and their representation in quantum mechanics'. Over twenty publications in *J. Math. Phys.* and *Annals of Physics* starting in 1970. Among the most relevant ones: *Ann. Phys.* (NY), 114, p. 243 (1978); 120, p. 402 (1979); 127, p. 458 (1980); (1986); Moshinsky, M., 'Collectivity and Geometry'. Over twenty *papers* dealing with collective models of the nucleus viewed from a group theoretical standpoint and appearing mainly in *J. Math. Phys.* Among the most relevant ones: *J. Math.*

*Phys.*, 25, p. 1555, p. 1565, p. 2815 (1984). Moshinsky, M., 'Pseudoatoms and atoms in strong magnetic fields', *Ann. Phys. (NY)*, 163, 1 (1985); Moshinsky, M., 'The Dirac oscillator', *J. Phys. A: Math Gen.*, 22, L817 (1989); Moshinsky, M., 'Art or Science: The symmetry Lie algebra for a Hamiltonian with accidental degeneracy', *Ann. Phys.*, 198, p. 103 (1990); Moshinsky, M., 'A relativistic cockroach nest', *Can. J. Phys.*, 72, p. 453 (1994); Moshinsky, M., 'Supermultiplets and relativistic problems', *J. Phys. A. Math. Gen.*, I. 29, p. 6027 (1996); II. 31, p. 6045 (1998); III. 31, pp. 10017-28 (1998); Moshinsky, M., 'Diffraction in time with dissipation', *J. Phys. A. Math Gen.*, 34, p. 4217 (2001); Moshinsky, M., 'Matrix representation of the Sturm-Coulomb problem in a magnetic field and its implications for chaos', *Rev. Mex. Fis.*, 46, supplement 1, (2003); Moshinsky, M., 'The relativistic and quantum mechanical and applications to bottomonium', *J. Phys. A. Gen.*, 36, p. 2163 (2003).