Laudatio by
Andrzej Trautman
delivered on 29 August 2005
on the occasion of conferring
the title of Doctor Honoris Causa
of Warsaw University
to Professor Roger Penrose

Rector Magnificus, Ladies and Gentlemen,

I feel honoured by the opportunity to speak about Sir Roger Penrose, the outstanding mathematician and physicist, my friend of many years.

Roger Penrose comes from a distinguished English family: his mother, Margaret, was a medical doctor, the father, Lionel, a Fellow of the Royal Society, was an outstanding geneticist. Lionel's brother, Sir Roland, was a renowned painter and historian of art, a friend of Picasso. Roger's older brother, Oliver, is a university professor specializing in statistical physics; the younger brother, Jonathan, has, ten times, won the British Chess Championship.

Educated in London (Ontario), London (England) and at Cambridge University, in 1957 Roger Penrose obtained there the Ph.D. degree in mathematics. Under the influence of Hermann Bondi, Paul Dirac and, especially, Dennis Sciama, he became interested in physics and, in particular in Einstein's theory of general relativity and in cosmology.

After the doctorate, Roger Penrose held research fellowships and professorial positions at several scientific institutions in England and the United States. In 1973 he was appointed Rouse Ball Professor of Mathematics at the University of Oxford. In 1998, after becoming Emeritus Professor at Oxford, he was given a position at the University of London as Gresham Professor of Geometry. He is also Distinguished Professor of Physics and Mathematics at Pennsylvania State University.

One of Roger's early publications on *A generalized inverse for matrices* (1955) containing the construction of a quasi-inverse of singular matrices, has found many practical applications; it is among his most often cited works.

In a paper on *The apparent shape of a relativistically moving sphere* (1959) Penrose showed that, contrary to the prevalent belief based on an incorrect application of the Lorentz transformations, such a sphere looks spherical to all observers, irrespective of their motion.

In 1960 Roger published *A spinor approach to general relativity*, a paper showing the merits of using two-component spinors in Einstein's theory. It played a major role in the subsequent work of Penrose and his school. As a result of this research, spinors, and in particular, the Newman–Penrose spin-coefficient calculus, have become the standard, most convenient tool for the study of the geometry and physics of gravitation and other relativistic fields.

In 1962, during his first visit to Poland, at an international conference on general relativity in Jabłonna, Roger Penrose introduced a new approach to analysing the geometry and physics of gravitation and other fields, based on the introduction of the light cone a infinity and on the resulting conformal compactification of space-time. The *Penrose diagrams*, that resulted from this approach, have become an important tool in relativistiv physics.

Early on, Penrose saw the need to connect, at a deep level, general relativity and quantum mechanics. Spinor and conformal ideas have led him to the discovery of a new, fundamental concept of twistors (1967). The twistor space associated with the conformally compactified Minkowski is a compact projective space of complex dimension 3. It provides a non-local description of space-time geometry and physics in terms of holomorphic data. In 1978 Roger gave an invited lecture at the International Congress of Mathematicians in Helsinki entitled *The Complex Geometry of the Natural World* outlining his views on the relations between relativity, quantum mechanics and complex-analytic geometry. In twistor theory, information about massless relativistic fields and solutions of non-linear equations can be encoded in data associated with sheaf cohomology groups. There is a Penrose transform, analogous to the Radon transform used, for example, in computerized tomography, that connects the two kinds of data. Pure mathematicians have extended twistor ideas to Riemannian spaces and established new, deep results on conformal and self-dual properties of such spaces. There are recent fascinating ideas on possible relations between twistors and superstrings.

Roger Penrose discovered new properties of black holes and obtained fundamental results in their theory and in cosmology. In 1971, he showed that energy can be extracted from rotating black holes. For a long time it was believed that the singularities appearing in collapse and in cosmology are due to the high symmetry of the models under consideration: in spherical collapse all particles converge to the common centre, but they seemed not to in generic situations. In a ground-breaking paper of 1965, Penrose showed that

under general and physically reasonable assumptions, a collapsing star would always lead to singularities in the geometry. The result was soon extended to cosmology; the theorems of Penrose, Geroch and Hawking on this subject are proved by an ingenious use, for the first time in physics, of methods of differential topology. Penrose formulated a *cosmic censorship* conjecture, according to which, the singularities resulting in collapse cannot be observed by external observers, because they are hidden by an optical horizon. This idea has generated much research that led to a clarification of the mechanism of collapse and the notion of black holes.

Roger Penrose has an extraordinary geometric intuition, imagination and insight. They much influenced his interests and research. Let me mention two more examples. Very early on, he introduced the *tribar*, an object impossible to construct for topological reasons.

Following the suggestions of Lionel and Roger Penrose, the Dutch artist M. C. Escher, has drawn many geometrical figures and several "impossible" ones, including the well-known waterfall and staircase.

Of great significance, also for physics, is Roger's discovery of a non-periodic tiling of the plane, requiring tiles of only two different shapes. Such structures have been later found to occur in quasi-crystals. According to Alain Connes, there is a non-commutative geometry associated with the Penrose tilings. They are also commercially available as a game and for decorative purposes.
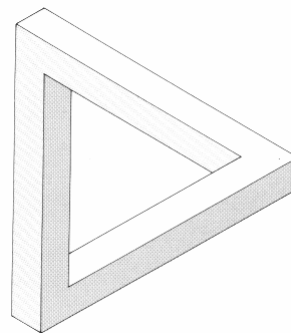
Roger Penrose published eight books. Three among them have the word *mind* in the title. This reflects his keen interest in the nature of intelligence, consciousness and, in general, the working of the human mind. He emphasises the necessity of including fundamental laws of physics when trying to explain mental processes. According to him, these processes are not algorithmic and, therefore, cannot be imitated by an 'artificial intelligence' in its strong form, an idea that he firmly opposes. Roger has unorthodox ideas on the relation between quantum mechanics and gravity, in particular on the possibility of an objective reduction of a quantum state due to gravitational interactions and on the role of gravity in determining a low entropy of the early universe.

These ideas have evoked vivid discussions and are considered, by some, to be controversial. Not being competent enough to take stand, I shall only comment by saying that a person who has never said anything controversial is unlikely to have ever said anything original.

Polish scientists have had close contacts with Penrose ever since his first visit here. He gave lectures at three more conferences in Poland, one of them being the Leopold Infeld commemorative meeting held at Warsaw University in 1998. Roger hosted in Oxford many visitors and several graduate students from Poland. In 1994 he was elected foreign member of the Polish Academy of Science. Several of his books were translated and published in Poland. The most recent, the monumental *Road to reality* is about to appear with the Prószyński Publishing House.

Penrose has received many honours for his scientific achievements. He is a Fellow of the Royal Society of London (1972) and a Foreign Associate of the United States National Academy of Sciences (1998). He obtained many prizes and other distinctions; let me mention only some of them: the Adams Prize from Cambridge University; the Wolf Prize for Physics awarded to him, jointly with Stephen Hawking, by the Knesset; the Heinemann Prize of the American Physical Society. In 1994 the Queen knighted him for services to science. Sir Roger Penrose has honorary degrees from several universities.

The current year has been declared to be the World Year of Physics. This commemorates the publication, in 1905, of the five fundamental papers of Albert Einstein. Roger Penrose played a major role in the development of many of Einstein's ideas. As part of the activities of the World Year of Physics, there is today in Warsaw a conference on *The Centenary of the Photon*. Sir Roger is giving a lecture at it. It is very appropriate that Warsaw University discerns today a honorary doctorate to Professor Roger Penrose.