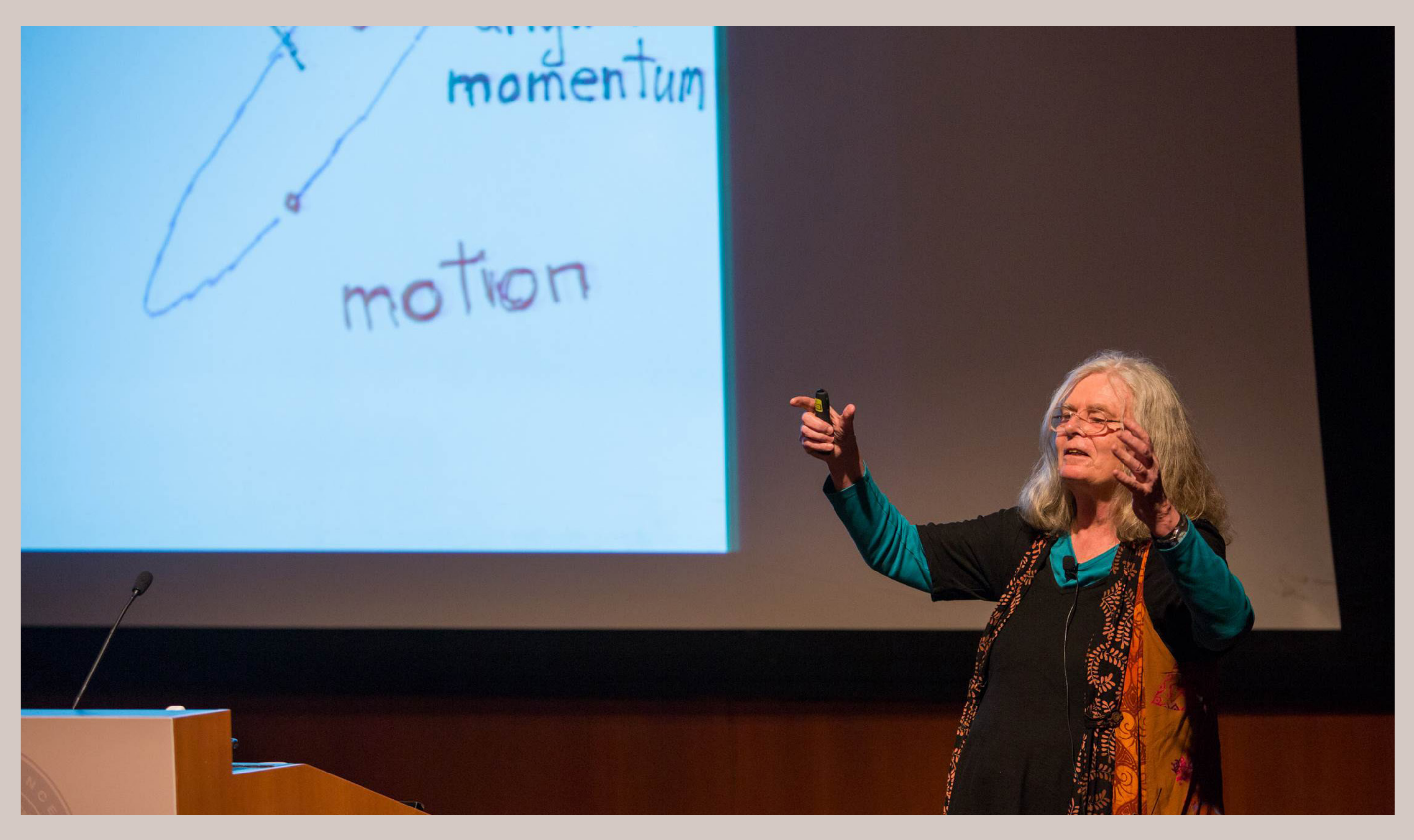

Karen Uhlenbeck giving a talk at the Institute for Advanced Study. Photo: Andrea Kane

A biography of Karen Uhlenbeck

By Professor Jim Al-Khalili FRS

In 1990, in Kyoto, Japan, Karen Uhlenbeck became only the second woman to give a Plenary Lecture at the International Congress of Mathematicians – ICM – the largest and most important gathering of mathematicians in the world. It is held every four years, and the first woman to do this was Emmy Noether in 1932. Such a shocking statistic reflects just how hard it is for many women to achieve the recognition they deserve in a male-dominated field. But by that point in her career, Uhlenbeck had already established herself as one of the world's preeminent mathematicians, having overcome many hurdles, both personally and professionally. In 2000, she received the US National Medal of Science. Yet for many, the recognition of her achievements should have been far greater, for her work has led to some of the most important advances in mathematics in the last 40 years.

Karen Keskulla Uhlenbeck, the eldest of four children, was born in Cleveland, Ohio in 1942. Her father, Arnold Keskulla, was an engineer and her mother, Carolyn Windeler Keskulla, an artist and school teacher. The family moved to New Jersey when Karen was in third grade. As a young girl, she was curious about everything. Her parents instilled in her a love of art and music, and she developed a lifelong love of the outdoors, regularly roaming the local countryside near her home.

Most of all, she loved reading, shutting herself away whenever she could to devour advanced science books, staying up late at night and even reading secretly in class. She dreamed of becoming a research scientist, particularly if it meant avoiding too much interaction with other people; not that she was a shy child, but rather because she enjoyed the peace and solitude of her own company. The last thing she wanted to do was to follow in her mother's footsteps and end up teaching – an attitude that would change dramatically later in life.

Uhlenbeck's love affair with mathematics developed only after she had started at university. Having been inspired in high school by the writings of great physicists such as Fred Hoyle and George Gamow, she enrolled at the University of Michigan, initially planning to major in physics. However, she soon discovered that the intellectual challenge of pure mathematics was what really excited her. It also meant she didn't have to do any lab work, which she disliked.

Graduating in 1964, she married her biophysicist boyfriend Olke Uhlenbeck a year later and decided to embark on postgraduate study. Already well aware of the predominantly male and often misogynistic culture in academia, she avoided applying to prestigious schools such as Harvard, where Olke was heading for his PhD and where competition to succeed was likely to be fierce. Instead, she enrolled at Brandeis University where she received a generous graduate fellowship from the National Science Foundation. There, she completed her PhD in mathematics, working on the calculus of variations; a technique that involves the study of how small changes in one quantity can help us find the maximum or minimum value of another quantity – like finding the shortest distance between two points. You might think this would be a straight line, but it is not always so straightforward. For example, if you have to drive through a busy city, the quickest route is not necessarily the shortest. Needless, to say, Uhlenbeck's contribution to the field was somewhat more complicated than this!

After a brief teaching period at MIT, she moved to Berkeley, California, where she studied general relativity and the geometry of space-time – topics that would shape her future research work. Although a pure mathematician, Uhlenbeck has drawn inspiration for her work from theoretical physics and, in return, she has had a major influence in shaping it by developing ideas with a wide range of different applications.

For example, physicists had predicted the existence of mathematical objects called instantons, which describe the behaviour of surfaces in four-dimensional space-time. Uhlenbeck became one of the world's leading experts in this field. The classic textbook, *Instantons and 4-Manifolds*, which she co-wrote in 1984 with Dan Freed, inspired a whole generation of mathematicians.

In 1971, she became an assistant professor at the University of Illinois at Urbana-Champaign where she felt isolated and undervalued. So, five years later she left for the University of Illinois at Chicago. Here, there were other female professors, who offered advice and support, as well as other mathematicians who took her work more seriously. In 1983, she took up a full professorship at the University of Chicago, establishing herself as one of the preeminent mathematicians of her generation. Her interests included nonlinear partial differential equations, differential geometry, gauge theory, topological quantum field theory and integrable systems. In 1987, she moved to the University of Texas at Austin to take up the Sid W. Richardson Foundation Regents' Chair in mathematics. There, she broadened her understanding of physics by studying with Nobel Prize winning physicist Steven Weinberg. She would remain at the University of Texas until the end of her working career.

Uhlenbeck's most noted work focused on gauge theories. Her papers analysed the Yang-Mills equations in four dimensions, laying some of the analytical groundwork for many of the most exciting ideas in modern physics, from the Standard Model of particle physics to the search for a theory of quantum gravity. Her papers also inspired mathematicians Cliff Taubes and Simon Donaldson, paving the way for the work that won Donaldson the Fields Medal in 1986.

Uhlenbeck, now back in New Jersey, remains a staunch advocate for greater gender diversity in mathematics and in science. She has come a long way from the young girl who wished to be alone. For a while, she struggled to come to terms with her own success, but now says she appreciates it as a privilege. She has stated that she is aware of being a role model, for young female mathematicians in particular, but that "it's hard, because what you really need to do is show students how imperfect people can be and still succeed. Everyone knows that if people are smart, funny, pretty, or well-dressed they will succeed. But it's also possible to succeed with all of your imperfections. I may be a wonderful mathematician and famous because of it, but I'm also very human." Karen Uhlenbeck is certainly a remarkable human.