Man of mystery

Roy Kerr is feted by the world's leading scientists. But few Kiwis have ever heard of him or his extraordinary contribution to the world of physics.

Ask any New Zealander to name the greatest New Zealand scientists and you're guaranteed to hear the name "Rutherford", followed by a long pause. If you're lucky, eventually the names of the Nobel and other prestigious prize-winners may be added, but it's almost certain that you won't hear the name Roy Kerr. And yet that name was enough to attract 50 or so top scientists from the world's premier science institutes to attend a symposium, the "Kerrfest", in Christchurch recently, to celebrate Kerr's 70th birthday and to honour this New Zealander who is credited with giving the "most important exact solution to any equation in physics". It is a mystery how someone described as "one of the top three relativists of the 20th century" could be so little known in his homeland where, at times, an extended transit stopover is enough to qualify for honorary Kiwi status.

The mystery deepens on meeting Kerr. Far from being one of the worthy, but perhaps less appealing, "brown cardy and sandals" types of scientist, he is, in his own words, a "party animal". Popularly credited with being "good-natured, good-looking and good at everything", he has a reputation as a "wheeler dealer" businessman, bringing back American sportscars and Rolls-Royces ("terrible cars!") from sabbaticals, that, coupled with his success as a sportsman and being a national representative and champion bridge player, would seem to invite notoriety rather than the opposite.

Or maybe Kerr's discovery was in one of those abstruse branches of science dealing with the truly esoteric – string theory or cosmic bubbles – that is beyond the public interest or imagination? On the contrary. Although the Kerr metric is probably not something any of us would care to encounter alone on a dark night, it deals with the one of most exciting branches of science today and one with arguably the highest public profile – the physics of black holes.

Perhaps it is simply part of the Kiwi dilemma that although we love science (and there is some very compelling evidence that we do), we're less interested in feting our scientists. (We're certainly less interested in paying them -- the New Zealand gold medal, the Rutherford, comes with the princely sum of zero dollars; the Aussie equivalent has a cool $250,000 attached.)

Fulvio Melia, Professor of Physics at the University of Arizona, commenting on the large and appreciative audience that attended the only public lecture held during the symposium, based on his highly acclaimed book The Black Hole at the Centre of Our Galaxy, made the same point. "I do not know of another city of this size in the world where over 400 people would turn up to a public lecture like this, and yet so far I haven't met a single New Zealander outside the university who has heard of Roy! That is extraordinary when it is his work which basically underpins everything we know about black holes."

Melia's lecture, like many others at the Kerrfest, concentrated on examining new observational evidence for these enigmatic objects, which, because of their extreme nature, are proving to be an extreme test bed for the fundamental parameters of general relativity. For example, Einstein's theory predicts that any rotating body will drag space with it. For slowly rotating bodies like Earth, the effect of this "frame dragging" is very, very small, but we expect that it should be measurable with the recently launched Gravity Probe "B". But for a rapidly rotating object such as a black hole, the effect would be enormous and is now believed to be a key contributor to the extreme energies produced in the largest supernova explosions and the huge particle jets that stream out from active galactic nuclei.

Yet, before Kerr's solution in 1963, very few scientists had thought that black holes could actually exist. The 18th-century English mathematician John Michell first postulated the existence of "dark stars", suggesting that there could be many massive compact stars where the gravitational force within a critical circumference was such that light could not escape. But this was before either the nature of light or gravitation was well understood.

Then Einstein published his gravitational-field equations in 1915, and the remarkable Karl Schwarzschild, while serving in the German army at the Russian front, was able to give the first exact solution, describing the geometry of space around any non-rotating star and predicting the extreme conditions of what we would now call a black hole, but which he called a singularity. Tragically, Schwarzschild died a few months later, though his "elegant and beautiful" calculations of the curvature of spacetime remained a primary tool for physicists for decades. The trouble was that Schwarzschild's geometry, elegant and crucial as it was, did not describe real stars that did spin, and a failure of imagination among physicists, Einstein included, to anticipate circumstances in which gravity could overwhelm all other forces, for example when a massive star would necessarily implode, led most scientists to conclude that black holes were of theoretical interest only. Indeed, Einstein declared, "Schwarzschild singularities [black holes] do not exist in physical reality!" Whether the singularities existed or not, the world's leading relativists spent the next 47 years searching for a solution to Einstein's field equation, which would describe the geometry of space around a rotating star.

Enter Roy Kerr. "Everybody who tried to solve the problem was going at it from the front, but I was trying to solve the equation from a different point of view – there were a number of new mathematical methods coming into relativity at the time and Josh [Goldberg] and I had had some success with these. I was trying to look at the whole structure – the Bianchi identities, the Einstein equations and these Tetrads – to see how they fitted together and it all seemed to be pretty nice and it looked like lots of solutions were going to come out. Then I hit a brick wall.

"Teddy Newman and Roger Penrose were working on a similar set of methods, but Teddy had come out with this as-yet unpublished theorem that basically 'proved' that my solution couldn't exist! Luckily, my neighbour, who was playing around with relativity, too, got hold of a preprint and I just scanned through it (I'm a lazy reader) and hit the crucial part which proved to me that my solution could exist! After that, I kept working like mad and found the solution in a few weeks." Which he published, elegantly, in a mere page and a half!

One might have imagined that after 47 years there would be plenty of cheering and instant fame and fortune, especially in the sort of neighbourhood where people "play around" with relativity. Not so. Although Kerr and his colleague Alfred Schild were well aware of the importance of his discovery, even anticipating its relevance to black holes, only a handful of other relativists had the faintest idea of its implications. In his classic book Black Holes and Time Warps, Kip Thorne, professor of theoretical physics at CalTech, recounts his vivid memory as a young graduate of the reaction to the 10-minute presentation by the young New Zealand mathematician at the Texas Symposium on Relativistic Astrophysics in 1963.

Only a few months before, Maarten Schmidt had discovered that quasars (quasi-stellar objects, previously radio sources) were in fact very distant objects with inexplicably and extraordinarily high energies and the astronomical

community was agog with the news.

"The astronomers and astrophysicists had come to Dallas to discuss quasars and they were not interested in Kerr's esoteric mathematical topic. So, as Kerr got up to speak, many slipped out ... others, less polite, argued in whispers ... many of the rest catnapped. This was more than Achilles Papapetrou, one of the world's leading relativists, could stand. As Kerr finished, Papapetrou demanded the floor, stood up and with deep feeling explained the importance of Kerr's feat. He, Papapetrou, had been trying for 30 years to find such a solution to Einstein's equation and had failed, as had other relativists."

The astronomers and astrophysicists may have nodded politely, but they still failed to grasp that it was this "esoteric" solution that would ultimately describe the mysterious source of energy of the very objects they were interested in.

Kerr doesn't remember Papapetrou, but he does admit to being "perhaps not the greatest expositor in the world!", which was possibly the reason his solution was originally to have been "discussed" by Penrose rather than presented by himself. But he wasn't having any of that! He recalls that when he first published, "it was like throwing out a chunk of meat in front of hungry lions – everyone wanted to grab a piece – it was pretty traumatic", and a few salutary experiences of the cut and thrust of the very competitive and not always ethical behaviour of top academics made him determined to keep at least this, his finest hour, to himself.

However, if the Kerrfest is anything to judge by, 40 years on, the gap between the relativists and the experimental physicists, the astronomers and the astrophysicists has all but closed and direct observational proof of the existence of a black hole from the shadow it casts against a background of radiating gas is an event definitely to be looked for on the horizon. Although there may be only a few who can appreciate the intricacies of principal null directions, S-branes, Killing vectors and the higher dimensional generalisations of the Kerr black hole (and, strangely, these seriously brainy guys seemed a lot more interested in these than in the nifty stuff about using a Kerr black hole as a wormhole to a parallel universe or as the ultimate solution to the energy crisis – theoretically, if you throw your rubbish into a Kerr black hole at just the right trajectory the emptied bin should come flying back with more energy!), many share Kerr's enthusiasm for the superb images that trace the activity of these extraordinary objects.

To see the universe in wavelengths other than the visual is to see "invisible" stars, luminous jets and the rich morphology of areas such as that surrounding Sagittarius A*, the black hole at the centre of our galaxy – the very "stuff" of rotating Kerr black holes. And the Kerr metric will be just as significant in a new wave of experimentation, that of detecting gravitational waves generated by such cataclysmic events as merging black holes. Kerr has already been nominated for a Nobel Prize by the legendary astrophysicist Chandrasekhar, and few would be surprised if, in view of the recent evidence for rotating black holes, that nomination was renewed.

Meanwhile, Kerr's 70th birthday celebrations ended, fittingly, with the announcement of another award – the prestigious Marcel Grossman prize, which he will receive in St Petersburg in 2006.