Tomalla Prize 2008 for Demetrios Christodoulou

Laudatio by Ruth Durrer

Dear Demetri, dear Dean, dear colleagues, students and friends

I am very happy to greet you here today to the Tomalla Prize 2008 ceremony.

The Tomalla Foundation for Gravity Research has been founded in 1982 according to the testamentary wishes of Dr Walter Tomalla, an Engineer from Berlin, who moved to Switzerland after the second war. With his foundation, Dr Tomalla wanted to promote gravity research in Switzerland and in the world.

The foundation periodically awards prizes for exceptional research in gravitation and it funds research fellows and visitors for gravity research at Swiss Universities. It can also promote research on gravity by other activities. It participated, for example in the costs of the edition of the collected papers of Albert Einstein, in an experiment to measure the gravitational constant G and in other scientific activities around gravity.

Two Tomalla Prize laureates (Subrahmanyan Chandrasekhar and Joe Taylor) have afterwards been awarded the Nobel Prize in physics and one (Andrei Sakharov) had obtained the Nobel Prize for peace.

The Tomalla Prize is awarded to a leading scientist in his field which may concern any aspect of gravity research be it experimental or theoretical cosmology, relativistic astrophysics, gravitational waves or mathematical research in general relativity.

This year, we are most proud to attribute the Prize to Professor **Demetrios Christodoulou** for his important contributions to general relativity, especially for his rigorous demonstration of global non-linear stability of Minkowski spacetime.

For the non-experts: global non-linear stability means that if at some initial time, space is nearly flat and slowly changing, this remains true as time goes on. This means that each observer, which moves freely (along a timelike geodesic) sees the spacetime around it remain nearly flat. Of course this is true in full generality only if spacetime is 'empty'. If there is matter present,

even very mild initial conditions can lead to black hole formation via gravitational collapse. Gravitational collapse is actually another of Demetrios' research topic on which he made very significant progress and which is the subject of his talk today.

Maybe some of you think "stability of Minkowski space, this is trivial, empty space cannot be anything else than flat". This is of course not true, there are gravitational waves, waves of spacetime curvature which have themselves energy and momentum and which can propagate freely through empty space much like electromagnetic waves. Hence the 'gravitational collapse of such waves' could in principle lead to singularities, to large deviations from Minkowski spacetime. Demetrios has shown that this does not happen if the waves are sufficiently weak initially. The proof of this statement is very difficult and long. I think an important point is also that Demetrios had to develop several very useful mathematical techniques to perform the proof. This is the reason that whenever you listen to a talk on hyperbolic differential equations or mathematical relativity you hear the name Christodoulou mentioned several times. The techniques he has developed now belong to the main tools when studying non-linear hyperbolic differential equations. I think it is fair to say that Demetrios is the most influential mathematical relativist of our generation.

Even though Demetrios first became really famous for his proof of global non-linear stability he subsequently made other very important contributions to general relativity, most notably on gravitational collapse. (I was fortunate to participate in a course by him on this subject when I was a post-doc in Princeton. There I learned that Demetrios is not only a brilliant scientist but also an excellent teacher.)

In a fundamental paper which appeared in the Annals of Mathematics 1994, Demetrios showed the existence of what we call 'naked singularities' by presenting several examples. Before this, there was a so called 'cosmic censorship' postulate, namely that all singularities, which we know do form in general relativity, are hidden behind a horizon and do, in this sense not affect an observer which is not falling into them. This is very important since it means that the worldlines of observers which do not fall in the singularity can be continued even after the formation of the singularity. The latter is never inside the 'domain of dependence' of such worldlines. Demetrios now showed that 'cosmic censorship' is not always obeyed and naked singularities

can form in the gravitational collapse of a scalar field (a hypothetical, not quite ordinary form of matter which offers itself to a simplified treatment). But then he went on, analyzed these singularities and showed that they are unstable (and therefore physically irrelevant).

Another of his results which I find extremely fascinating is known as 'Christodoulou's memory effect' or the 'Christodoulou drift'.
Demetrios has shown that a non-linear effect can built up during the passage of a gravitational wave. After the passage of a gravity wave burst in a laser interferometric gravity wave experiment, this effect leads to a permanent displacement of the two mirrors which are bouncing back and forth the laser light. Even though this effect is even more difficult to measure than ordinary gravitational waves, since it is not oscillating, it may not be out of range of future experiments.

Demetrios was born in Athens, Greece. His exceptional mathematical talent was discovered early, and at the age of 19 he terminated his undergraduate studies with a master at Princeton University. The main result of his master thesis on reversible and irreversible transformations in black hole physics, is published as a single author PRL. Only a year later, at the age of 20, he finished his PhD also at Princeton University. After that he had several positions at CalTech, at CERN, at the Courant Institute in New York, at Princeton University and since 2001 he is professor for mathematics and physics at ETHZ. (This is only the second time that we can honor a 'Swiss' researcher with the Tomalla Prize.)

Of course, the Tomalla Prize is not the first honor for Demetrios. He obtained other prestigious awards. Among them let me just mention the Otto Hahn Medal, the MacArthur Fellows Award, the Bôcher Memorial Prize and several honorary doctorates.

But let me stop here. Demetrios is with us today and he will take us on a journey from the geometrical basis of general relativity to his results on gravitational collapse and the formation of unstable naked singularities. His colloquium is entitled

The Fabric of Spacetime