# Gravitational radiation in spacetimes of positive cosmological constant: description for the general public.

The observations of the universe and the registration of the incoming signals in the recent years would have provided Albert Einstein with two important facts. The first one - the necessity to include a positive cosmological constant to the Einstein's theory – has been concluded based on the observed rate of the expansion of our universe. The expansion accelerates and based on the relativity theory such an effect can be explained only by the presence of a cosmological constant. Although Einstein has considered such a correction to his theory, he had an opposite motivation, namely he wanted to stop the expansion of the universe, which at that time was believed to be static. The second fact is the confirmation of the existence of gravitational waves. Recently, they have been directly detected – detection has occurred multiple times now. What an irony, even nowadays Einstein would not be ready to accept these facts at once. The theory of gravitational waves has been examined with the assumption of the zero cosmological constant. Generalization to nonzero cosmological constant is really not that trivial. Most of all, Einstein could not prove the existence of gravitational waves, that he previously predicted. Moreover, he did not believe that they were real, which has been expressed in one of his papers.

Einstein's doubts have not been resolved during his lifetime, as he died in 1995. Finally the work young Trautman published in 1958 and that was continued by Bondi, Pirani and Sachs in the early 1960s proved, that the theory of general relativity implies the existence of gravitational radiation. Mathematical formulation of Trautman-Bondi-Pirani-Sachs theory has been developed by Penrose and Hawking. The key to the solution of the problem was the understanding of the asymptotical structure of space-time and its properties, when the sources are very far. The theory of asymptotic space-time has been further developed and now it is one of the fundamental tools used for the general description of the relativistic, isolated systems. However, in this theory Einsteins equations without cosmological constant are assumed. The introduction of the tiniest nonzero value of this constant breaks all the asymptotic theory. It has to be developed from the beginning. And that is what this project is about. We plan to develop the theory of gravitational radiation that is in line with the positive cosmological constant.

The presence of the positive cosmological constant leads to new phenomena – the so called cosmological horizons. The method that we propose in the project uses this mechanism. Cosmological horizons are a special case of non-expanding horizons or weakly isolated horizons, that have been the topic of our research in Warsaw for many years now. We have been examining them as a generalization of the black holes. Now we will make use of them in a different context. From our previous work it follows that the isolated horizons have many properties surprisingly applicable to the new description of gravitational radiation. The theory that we plan to develop will depend, in a continuous way, on the cosmological constant and will be reduced to the known theory in case of vanishing of the constant. This type of extension of the theory of gravitational radiation is not known yet, however it is highly desirable.