Spacetime globe:
a teaching proposal for the didactics of Special Relativity

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Abstract. Special Relativity introduces students to Modern Physics, whose importance in the Italian High Schools is increasing. Nevertheless to face the difficulties both teachers and students encounter different solutions have been developed.
We present an experimentation regarding the teaching of Special Relativity we performed in last year classes of High Schools, namely those specializing in scientific studies. In this project a mechanical instrument was used which allows to explain and show Lorentz's transformations, exploring by hands the effects of a change of reference frame. Teachers and students were able to deal "by eye" with relativistic phenomena.

1 Introduction

The Theory of Special Relativity is a milestone in the history of Physics: it completes the description of classical mechanics and represents the base for the understanding of new phenomena. However learning and teaching difficulties from teachers and students still persist as highlighted in literature ([1-5]) even if different strategies has been developed in order to overcome them ([5]), also adopting virtual resources ([6-7]). Both Dimitriadi ([2]) and Alstein ([4]) pointed out that most of the problems lays in understanding the frames of reference, a key concept as Special Relativity focuses over the change between different inertial frames.

In this direction, the analysis on the four-dimensional spacetime geometry carried out firstly by Minkowski ([8]) and later suggested as a teaching approach from Taylor and Wheeler ([9]) is a powerful instrument. The importance is documented in the literature that recognises the use of Minkowski's diagrams as valid tools in the teaching of Special Relativity ([3, 10-12]).

2 Spacetime globe

In our experimentation we used a *spacetime globe* as an educational alternative to Minkowski's spacetime diagrams. The device is shown in Figure 1 and it has been built by the mechanical laboratory of our department, reproducing the original one from the YouTube channel *MinutePhysics* [13].

This instrument is a Minkowski's spacetime diagram: each dice is an event that took place at time t in the x position. Dices' coordinates are identified using the grid where the vertical axis is the ct one while the horizontal axis is the x one. Thus, the instrument can be used to map the position of an event in bi-dimensional spacetime and to study one-dimensional motion.

With a visual and quantitative approach this instrument enables to investigate the change between reference frames and their consequences (relativistic phenomena) manually acting on the bars. As we demonstrated ([14]) thanks to the hyperbolas-shaped tracks when the reference frame is changed, the position of each dice is mapped into its transformed under Lorentz's transformation.

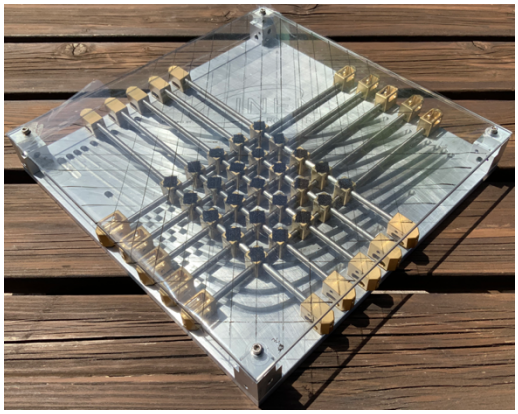

Fig. 1 Our version of the spacetime globe

3 Conclusion

In order to investigate the possible effectiveness of this device as a didactic tool, we conceived and carried out a teaching project with some High Schools of Rome. The instrument found a great acceptance from both students and teachers who were interested in its functioning.

From a didactic point of view, we submitted to the students a pre-test and a post-test with open and close question: the former was addressed to the main concepts of classical mechanics while the latter to the ones about Special Relativity. We are going to briefly present the results.

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