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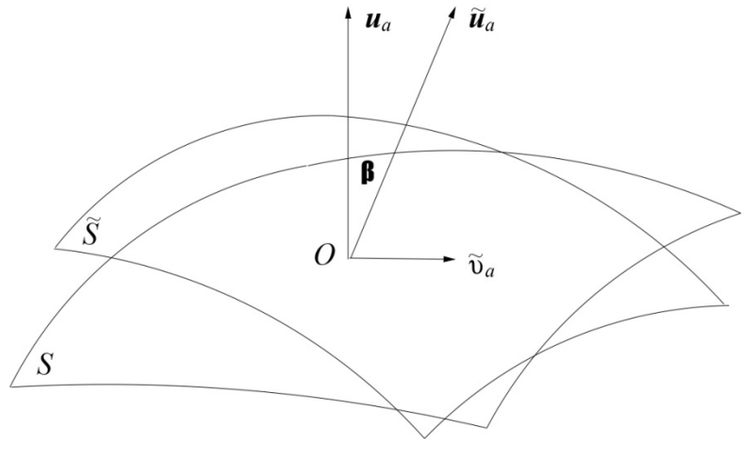
Hellenic Foundation for Research & Innovation

Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment



Title of the research project: Tilted Cosmology

Principal Investigator: Christos Tsagas

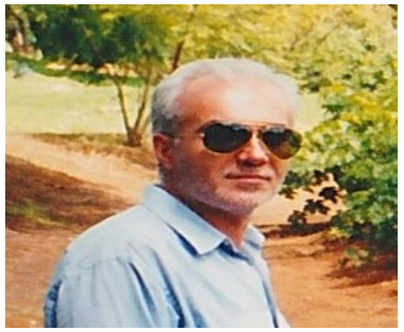
Reader-friendly title: CosmoTilt

Scientific Area: Physical Sciences

Institution and Country: HFRI, Greece

Host Institution: Aristotle University of Thessaloniki

Collaborating Institution(s): Oxford Univ., Univ. of Ioannina



Budget: 200.000

Duration: 36 months

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Research Project Synopsis

Typical galaxies in the universe do not move along with the smooth global expansion, but have their own ``peculiar '' velocities. Our Galaxy, for example, has peculiar velocity in excess of 600 km/sec, with respect to the universal expansion. Relative motion effects are known to trigger illusions that can mislead the observers to a false sense of reality. The history of Astronomy is full of such examples. In cosmology also, bulk peculiar flows can ``contaminate'' the observations and thus trick the observers into an erroneous interpretation of their data. The research project underway uses relativistic cosmological perturbation theory to study these large-scale peculiar motions. This is achieved by introducing the so-called ``tilted'' cosmological models, with a pair of observers moving relative to each other. The aim is to shed light onto the origin, the evolution and the implications of these bulk flows. More specifically, to investigate how and to what extent the peculiar motion of our galaxy could affect our observations and compromise our understanding of the universe we live in.

Project originality

Standard cosmological studies typically bypass the effects of peculiar motions. Nevertheless, the presence of large-scale bulk flows has been repeatedly verified by numerous observations. Moreover, several surveys have reported peculiar flows larger and faster than those predicted by the standard theoretical models. The latter, however, use Newtonian gravity rather than general relativity and therefore do not account for the fundamental differences between the two theories. More specifically, in relativity, observers moving with respect to each other have a different measure of time and space. Also, in Einstein's theory, gravity is no longer a force but the result of spacetime curvature. These fundamental differences mean that the Newtonian and the relativistic treatments of cosmological peculiar motions can arrive at very different results and conclusions. The project underway aims at identifying these differences and studying the changes they introduce to standard cosmology.

Expected results & Research Project Impact

So far, the available studies of large-scale peculiar motions in cosmology have been few and sparse. This makes ``Tilted Cosmology'' the first systematic theoretical treatment of the subject. We anticipate that our research will not only facilitat e a better understanding of the mechanisms that generate and sustain these bulk peculiar flows, but that it will also identify their implications for our interpretation of the cosmological data. Fundamental cosmological measurements, such as those of the Hubble parameter and of the deceleration parameter, are affected by relative-motion effects. This in turn can lead to the misinterpretation of the data and to erroneous conclusions about the state of our universe. It is therefore imperative to identify the degree such key observations are contaminated by the peculiar motion of our galaxy relative to the smooth universal expansion.

The importance of this funding

I have been interested in the role and the implications of cosmological peculiar flows for a number of years. The funding of the ``Tilted Cosmology '' project by HFRI has allowed me to proceed in systematic way, by putting together a research group devoted to the task and also by bringing into it synergies from other universities in Greece and abroad. The budget also includes funding for meetings, workshops and conferences, as well as travel and visits. The program commenced in February 2020 and although the ensuing pandemic has not left its activities unaffected, the latter have continued and they will resume fully once we return to normality.

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COMMUNICATION

185 Syggrou Ave. & 2 Sardeon St. 2
171 21, N. Smyrni, Greece
+30 210 64 12 410, 420
communication@elidek.gr
www.elidek.gr