Line of research proposal

title:	Fields on Curved Backgrounds
acronym:	FoCus
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co-PI:	S. Liberati (SISSA)
members:	S. Sonego (Udine University)
	T. Tanaka (Kyoto University)
	E. I. Guendelman (Ben-Gurion University)
	A. Flachi (Keio University)

Abstract

The theory of quantum fields on curved backgrounds is a classic subject in theoretical physics that has contributed to the development of fundamental and far reaching ideas, from quantum cosmology to black hole thermodynamics. In this more general framework than standard quantum field theory, we need new conceptual tools, as, often, we cannot consistently use standard techniques and ideas. With this proposal we aim to create a collaborative environment to study in detail open problems in the field, and the related phenomenology, with an interdisciplinary approach.

Objectives

1. To develop original research as detailed in the following section: the main field of interest will be the foundations and recent applications of quantum field theory on curved backgrounds.

2. To organize topical workshops, and exchange activities with leading scientists in the field of interest for this project.

3. To apply for grants to international agencies (within and outside EU).

Description

This proposal for a line of research at the IFPU, *Fields on CUrved backgrounds* (FoCus), is centered on the study of the dynamics of (quantum) field on curved backgrounds, like (but not restricted to) spacetime. This is a classic subject, that has already contributed deep theoretical ideas, most notably, Hawking radiation, and the quantum evolution of cosmological perturbations in the early universe.

Indeed, the theory of quantum fields on curved backgrounds is phenomenologically rich, and it is interested in processes that populate the realm where we need to take into account effects due to the presence of a non-negligible gravitational field/curvature, while the gravitational field itself can still be treated at the classical level. Of course, as a rule of thumb, we expect a direct contribution of nonperturbative quantum gravity above 10^{19} GeV, where quantum field theory in curved backgrounds would, then, become an inadequate description. However, this still leaves a wide energy range over which we expect to be able to apply the ideas, on which FoCus is centered.

Indeed, despite great progress in the last decades, there are still many open issues in the theory of quantum fields on curved backgrounds that have to be addressed. Some are fundamental, and related to the fact that not all the concepts that we effectively use in ordinary quantum field theory can be extended to curved backgrounds (textbook example, are the concepts of vacuum and particle). Others are, instead, related to the phenomenology that is becoming, or could become, accessible in concrete experiments (e.g., analog models of gravity), and refined observations (e.g., CMB and large scale structure). Additionally, new ideas have been, recently, considered, which have a strong interdisciplinary nature, and that apply results and techniques of quantum field theory on curved backgrounds in diverse contexts, like, spontaneous/anomalous symmetry breaking, anomalous effects of dense matter under rotation, chiral magnetic effects and condensates in connection with Schwinger mechanism, just to name some of them.

With this proposal we intend to develop/continue constructive collaborations to study in detail some of the ideas outlined above, both, at the fundamental level, and in connection with more concrete applications. For instance, we have in mind the study of quantum effects in the early universe, in particular in presence of quantum tunneling, e.g. to understand potentially observable signatures, and to provide a technically solid framework for existing phenomenological models (with this motivation, we would like the scientific committee to consider prof. T. Tanaka (Kyoto University), and prof. E. I. Guendelman (Ben Gurion University), as external participants to this proposal). The study of quantum effects in black hole spacetimes (black hole entropy and thermodynamics) is an always hot topic in the field, and FoCus will definitely benefit from the proven expertise of prof. S. Sonego (Udine University), whom we would also like to consider as a member of this proposal. Finally, for recent phenomenological ideas, like symmetry breaking in curved spacetime and related effects, we asked to join, again as an external scientist, prof. A. Flachi (Keio University). We think that this constitutes a well assorted team to support the PI and co-PI in reaching the goals of this proposal.