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Time-Dependent Quantum Scattering in 2+1 Dimensional Gravity

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Abstract: The propagation of a localized wave packet in the conical space-time created by a pointlike massive source in 2+1 dimensional gravity is analyzed. The scattering amplitude is determined and shown to be finite along the classical scattering directions due to interference between the scattered and the transmitted wave functions. The analogy with diffraction theory is emphasized.

1. Introduction

The time-dependent scattering problem was solved in the case of the Aharonov-Bohm interaction in [1]. This author considered the time evolution of an electrically charged well-localized wave packet in the presence of a magnetic vortex. The main result in that work is the analysis of the forward direction, where the wave packet undergoes a self-interference; the probability density current was shown to be finite.

The question arises if a similar analysis can be carried out in 2+1 dimensional gravity. By this we mean to consider the scattering of a wave packet by a static source in planar gravity, to find the scattering amplitude, and to determine the behaviour of the wave packet along the directions where self-interference effects are significant.

The classical theory of 2+1 dimensional gravity, as well as its interpretation as a conical space-time, was presented in [2]. The quantum-mechanical scattering problem for two scalar particles interacting only gravitationally in 2+1 dimensions was first solved in [3] by reducing the problem to the motion of a free particle on a cone. A closely related procedure was put forward in [4], this time derived from a partial wave decomposition. Needless to say, both methods yield the same scattering amplitude. These works showed that in the case of 2+1 dimensional gravity the forward direction is not exceptional; it is at the classical scattering angles where self-interferences take place.

A further step was taken in [5]. These authors not only generalized the previous results to the case of spinning sources, but also pointed out an interesting analogy

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