Almost a century ago, Edwin Hubble and other astronomers observed that the wavelength of the light emitted by stars is stretched, so the light is seen as “shifted” towards the red part of the spectrum. With this redshift understood as a Doppler effect for electromagnetic waves, it means that the galaxies are receding. The universe is expanding due to the enormous energy stored in stars and galaxies. The measurement of redshift remains until the present day as the most accurate way of measuring the speed of receding galaxies. Very accurate measurements accomplished only twenty years ago revealed that this expansion is accelerated by mysterious “dark energy”. In Einstein’s theory of general relativity, dark energy originates from the “cosmological constant,” which curves spacetime at very large distances.

The experiments performed at the Large Hadron Collider and other particle accelerators have a very different character than astronomical observations. These experiments measure the probabilities of particle collisions depending on their energy and momentum. It is the realm of quantum physics, with the collision probabilities determined by the “scattering amplitudes”. The energies of colliding particles are extremely high, therefore the accelerator experiments probe spacetime at very short distances, many orders of magnitude shorter than the cosmological scales. Nevertheless, like the redshift, they are sensitive to spacetime curvature because it changes the trajectories of particles before and after collisions.

The proposed research will investigate how the curved fabric of spacetime affects elementary particle energy collisions. The study will be done in the simplified framework of “de Sitter universe” with constant curvature. The scattering amplitudes describing the elementary particle collisions will be studied in curved spacetime. The question of whether the effects of curvature can be observed in accelerator or laboratory experiments will be addressed. The goal is to discover new connections between elementary particle physics and astronomical observations.

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