Research Plan

Our universe is approximately described by the Friedmann universe model. This model is completely determined by three parameters; H_0, Ω_K and Ω_Λ. H_0 is the present expansion rate of the universe. Ω_K represents the spatial curvature and Ω_Λ represents the cosmological constant. Determination of these parameters is one of the greatest goals of cosmology.

In order to determine these parameters, we must rely on the various observations. The relation between the apparent luminosity and the redshift of the stellar body brings important information of these parameters since the apparent luminosity are closely related to the expansion law of the universe. To be more precise, the observed m-z relation is compared with the theoretical m-z relation in the Friedmann universe and the best-fit parameters are chosen.

The Friedmann universe model is derived by assuming the spatial homogeneity and isotropy of the universe. Although there do exist inhomogeneities like galaxies and clusters of galaxies, this assumption become valid after averaging over large scales. But the light beams are directly affected by these small scale inhomogeneities. If a light beam passes near the inhomogeneity, it suffers the gravitational lens effect, which results in the bending of the trajectory and magnification or demagnification the light. Therefore, we cannot make a simple comparison mentioned above.

The currently popular universe model is the accelerating one. The cosmological constant is needed to explain the acceleration since the spatial flatness of the universe is suggested by the observation of the cosmic microwave background radiation. If the cosmological constant exist, a new problem about its origin arises. One of the evidences for the accelerating universe is that the celestial bodies looks fainter than in the case of decelerating universe. Therefore, we could solve the problem of cosmological constant if we find the mechanism to make the apparent luminosity fainter.

In the future work, I will deal with this problem in terms of the gravitational lens effects by the inhomogeneities. It is known that the apparent luminosity becomes fainter if the light beam travels in low density regions. This is the point of this work. In order to realize the situation, I use the Swiss-cheese universe model in which the blackhole solutions are embedded. I can estimate the effect of the gravitational lens effect by studying the m-z relation in this model.

We must consider the bundle of light rays in order to investigate the luminosity under the geometric optics approximation since the luminosity is defined by the sectional area of the bundle. If a bundle of light rays suffers strong gravitational lens effect, it experiences caustics. This means that the non-trivial configuration of the rays appear. These non-trivial configurations are thought to occur frequently since the light beams from the distant celestial bodies ($z \gtrsim 1$) are expected to experience strong gravitational lens effects at least once. In the forthcoming observations, the targets extend to $z > 1$. Therefore it is important to study these strong gravitational lens effects.