Study Plans

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Estimation of solutions of cosmic strings with a symmetry

Previously I have discussed the analytical solutions of stationary rotating cosmic strings in Minkowski spacetime. There are some Killing vector fields in Minkowski spacetime, then there some equations of motion of cosmic strings, the world sheet of which are tangent to some Killing vector fields, not only the previous case. It has been also indicated by Ishihara and Kozaki, who are my collaborators, that there are only seven independent equations which determine the motions of cosmic strings with symmetries. Then, as one of my future plans, I will consider how we reduce these seven equations of motion of cosmic strings to ordinary differential equations. Especially in the analytically solvable case among the seven cases, it is expected that these solutions will be characterized by two parameters as well as the stationary rotating case.

In the spacetime, except Minkowski spacetime, it is able to be discussed whether the reduction can be adopted. It is also my future plan what type of equations of motion of cosmic strings can be reduced to ordinary differential equations in any spacetime. As an example, in Schwarzschild spacetime, static and spherically symmetric spacetime, it has been found that the equations of motion of stationary rotating cosmic strings can be reduced to ordinary differential equations as well as in Minkowski spacetime. In that case, the analytic solutions have not derived, but it will be also my future work what parameters determine the solutions.

Adiabatic evolutions of stationary rotating cosmic strings

Previously I have obtained the informations of waveforms of gravitational waves from stationary rotating cosmic strings. Then, the energy, angular momentum of cosmic strings are losed because of gravitational wave radiations. It is found that the loss of these quantities can be estimated by amplitudes of gravitational waves radiated from the cosmic strings, and these are characterized by two parameters, which characterize the solutions of cosmic strings. Because of the losses of these quantities, it is expected that the configurations of cosmic strings are evolved, then assumed stationarity can not be satisfied apparently. But fortunately, actually the stationarity can be satisfied adiabatically, as follows: Assuming that the original energy of cosmic strings is $E_{\rm st}$, the energy loss rate by gravitational wave radiation is $\dot{E}_{\rm GW}$, as the result of numerical calculation, the value $\dot{E}_{\rm GW}/E_{\rm st}$ can be satisfied the relation: $\dot{E}_{\rm GW}/E_{\rm st} \lesssim 10^{-3}\mu/\Omega$, where Ω is angular velocity of cosmic strings, and μ is tension of cosmic strings. In stead of the energy, the relation is satisfied for the angular momentum. Due to the CMB observation, e.g. WMAP(Wilkinson Microwave Anisotropy Probe), a constraint from this observation to the cosmic string tension was calculated as $\mu \lesssim 10^{-7}$. As the result, it has been found that the approximation of stationarity, i.e., adiabatic evolution is satisfied.

On the adiabatic approximation, we will obtain the adiabatic evolutions of two parameters, i.e., configurations of cosmic strings, by consideration of the energy and angular momentum loss rates. I will conclude what are the end states of stationary rotating cosmic strings eventually from arbitrary configurated cosmic strings, along the adiabatic evolution. Concretely I have to conclude which is the end state, stationary rotating cosmic strings which configurations are helical or the static and straight one.