

## **Integrability of cohomogeneity one Nambu–Goto string:**

The motion of point particles are described by geodesics in a spacetime. The geodesic equation is equivalent to the dynamical system whose Hamiltonian is spacetime metric, and so the existence of a sufficient number of conserved quantities makes the system integrable. Geodesics in a spacetime admitting Killing vector fields are integrable if a sufficient number of the conserved quantities associated with the Killing vectors exists. Kerr spacetime admits only two Killing vectors, whereas the geodesics are integrable. This is well-known as an example of "hidden symmetry" generated by a second order Killing tensor field.

Similarly as hidden symmetry corresponding the motion of point particle (0-dimensional object), there maybe exists another "hidden symmetry" corresponding the motion of string (1-dimensional object). So, we consider the hidden symmetry assuring that the motion of string is integrable.

Nambu–Goto string described by the action proportional to the area of the world sheet of the string is a natural generalization of geodesic. The condition that all Nambu–Goto strings are integrable is too strong, and it is difficult to treat. So, we limit our consideration to cohomogeneity-one string (a string whose world sheet is tangent to a Killing vector field of the target space). All cohomogeneity-one strings in the maximally symmetric spacetimes are integrable, that is not the case for the quasi maximally symmetric spacetimes. We investigate the criterion whether all cohomogeneity-one strings are integrable or not. We also extend the discussion to integrability of cohomogeneity-one membranes.

## **Loop quantum gravity and complexity:**

Loop quantum gravity (LQG) is an approach to non-perturbative and background independent quantization of general relativity. Spin-network states span the kinematic state space of LQG as an orthonormal basis. Spin-network state is labeled with spin-network, which is a graph whose edges are colored by half integers satisfying simple relations at the vertices. In LQG, Geometrical operators (area operator and volume operator) are constructed. Their eigenstates are spin-network states and they have discrete eigenvalues.

From informational viewpoint on volume operator in LQG, following conjecture is suggested: A logic gate must have finite minimum volume, and number of logic gates contained within a region of space are bounded by the volume of the region.

It seems to say "Complexity is Volume."

We want to consider the possibility of LQG as a foundation where complexity is discussed.