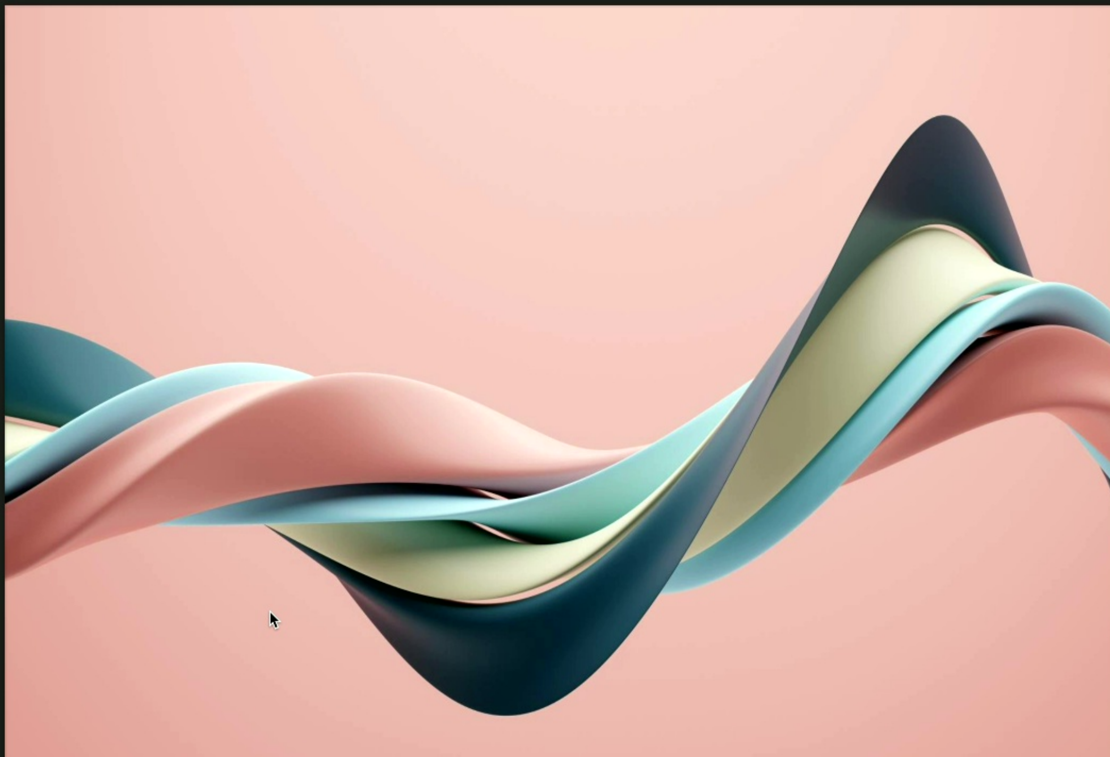
Title: The Bulk Model of Dissipative Dynamics On Lie Group

Speakers: Afshin Besharat

Collection/Series: Celestial Holography Summer School 2024

Date: July 24, 2024 - 3:40 PM

URL: https://pirsa.org/24070082



The Bulk Model of Dissipative Dynamics On Lie Group

Perimeter Institute

July 24, 2024

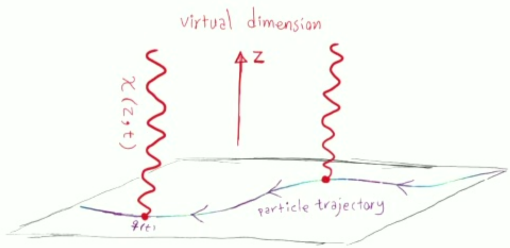
Afshin Besharat

McMaster University

PhysRevE.109.L052103 + A Work In Progress

The Bulk Model of Dissipative Dynamics

When a body moves in a dissipative environment, it drags the medium with itself which causes dissipation. We model this phenomena by promoting the body's degrees of freedom $q^i(t)$ into a field $\chi^i(z,t)$ field living in an extra virtual dimension z.



The Action Functional

- We want to model the dissipative dynamics which nonlinearly realizes the symmetry:

$$g = e^{\chi^i G_i}\,, [G_i, G_j] = C^k{}_{ij} G_k \qquad (1)$$

- The action functional must be built out of the covariant derivatives with respect to the symmetry group: Cartan's formalism:

$$g^{-1}dg = \Omega^i_j \chi^j G_i\,, D_\mu \chi^i = \Omega^i_j \partial_\mu \chi^j \qquad (2)$$

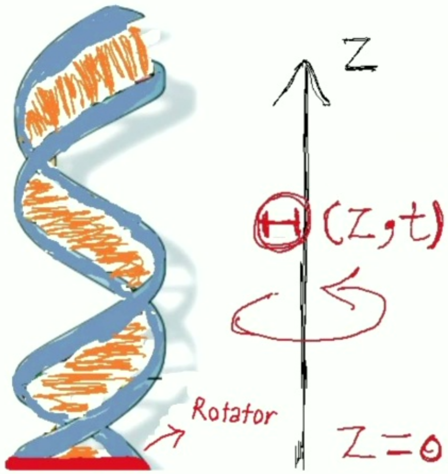
- It must encode the gapless dissipative processes

$$S[\chi(z,t)] = \int_{z,t} \Big(\gamma_{ij} D_\mu \chi^i(z,t) D^\mu \chi^j(z,t) + \frac{f_{ijkl}}{\Lambda^2} D_\mu \chi^i(z,t) D^\mu \chi^j(z,t) D_\nu \chi^i(z,t) D^\nu \chi^j(z,t) + ... \Big)\,. \qquad (3)$$

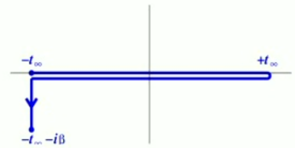
An Example: A Two Dimensional Rotator Parameterized By ISO(2)

For a two-dimensional dissipative rotator in the $x_1 - x_2$,

$$x_1(t) \to X_1(z,t)\,, x_2(t) \to X_2(z,t)\,, \theta(t) \to \Theta(z,t) \qquad (4)$$



The Schwinger-Keldysh Formalism



- If we integrate out the bath at $z > 0$, with the assumption that it is at finite temperature $T = \frac{1}{\beta}$, we obtain the effective dissipative dynamics of the body at $z = 0$.
- Doubling the field $\to$ the forward in time χ_+ and backward in time χ_- fields.
- Changing the path integral variables from $\chi_\pm$ the classical χ_c and quantum χ_q fields
- χ_c transforms similar to $\chi_\pm$, and χ_q encodes the difference between χ_+ and χ_-: Nonlinear definitions of the classical and quantum fields

Perturbative Influence Functional From Schwinger-Keldysh Formalism: The High Temperature Limit

- With the boundary conditions $\chi^i_c(z=0,t) = \varphi^i(t)$ and $\chi^i_q(z=0,t) = \zeta^i(t)$, then the influence functional reads

$$i\mathcal{I}[\varphi(t), \zeta(t)] = -\frac{4}{\beta}\int_t \gamma_{i'j'} \Omega^{i'}_i(\varphi(t)) \Omega^{j'}_j(\varphi(t)) \zeta^i(t) \zeta^j(t) - 2i \int_t \gamma_{i'j'} \Omega^{i'}_i(\varphi(t)) \Omega^{j'}_j(\varphi(t)) \dot{\varphi}^i(t) \zeta^j(t) + ... \qquad (5)$$

- This gives the covariant Langevin equation with noises.
- One can go beyond the Gaussian noise perturbatively.