Quantum Counterpart of Classical Dynamics

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Cosmology and Particle Physics:

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Ana Fernandes Alexandre (Cosmology, GUTs)

Giordano Cintia (Superfluid DM, Quantum Breaking)

Lukas Eisemann (Quantum Breaking, Black Holes, Enhanced Memory Cap.)

Manuel Ettengruber (Joint Supervision by Caldwell & Dvali, IR Neutrino Ph.)

Anna Jankowsky (SUSY GUTs)

Oleg Kaikov (Quantum Breaking, Black Holes, Enhanced Memory Capacity)

Emmanouil Koutsangelas (Dark Matter as Many Copies of SM, Axions)

Andrei Kovtun (Quantum Breaking)

Marco Michel (Quantum Breaking, Black Holes, Enhanced Memory)

Otari Sakhelashvili (Non-perturbative QFT, Entropy Bound and Unitarity)

Juan Valbuena (Interactions of Topological Defects)

Michael Zantedeschi (Quantum Breaking)

From 2020:

L. Berezhiani, "On Effective Theory of Superfluid Phonons," Phys.Lett.B **805**, 135451

G. Dvali, "Entropy Bound and Unitarity of Scattering Amplitudes," [arXiv:2003.05546].

A. Kovtun and M. Zantedeschi, "Breaking BEC," JHEP **07**, 212

G. Dvali, A. Kehagias and A. Riotto, "Inflation and Decoupling," [arXiv:2005.05146].

G. Dvali, L. Eisemann, M. Michel and S. Zell, "Black hole metamorphosis and stabilization by memory burden," Phys.Rev.D **102**, no. 10, 103523

A. Kovtun and M. Zantedeschi, "Breaking BEC: the fast and the quantum," [arXiv:2008.02187].

G. Dvali and A. Jankowsky, "Absence of μ-Problem in Grand Unification," [arXiv:2009.07762].

G. K. Karananas, M. Michel and J. Rubio, "One residue to rule them all: Electroweak symmetry breaking, inflation and field-space geometry," Phys.Lett.B **811**, 135876

L. Berezhiani and M. Zantedeschi, "On Evolution of Coherent States as Quantum Counterpart of Classical Dynamics," [arXiv:2011.11229].

G. Dvali, "S-Matrix and Anomaly of de Sitter," [arXiv:2012.02133].

Quantum Counterpart of Classical Dynamics

Classical description: Φ_{cl}.

Since the world is quantum, sometimes a question arises about possible quantum effects.

Semi-classical method: $\Phi_{cl} + \delta\phi$.

Quantum Counterpart of Classical Dynamics

Dvali, Gomez '11, '12, '13, Dvali, Gomez, Zell '17

Quantization of fluctuations around the fixed classical background has drawbacks.

Semi-classical back reaction on Φ_{cl} does not account for all the quantum effects.

A more fundamental description should be in terms of a quantum state with desirable properties; e.g. a coherent state built around a well-defined vacuum.

An example:

Hydrodynamic eqs.: $(\text{water}) \longrightarrow (\text{water})$

Realistic evolution: $(\text{water}) \longrightarrow (\text{water})' + (\text{vapor})$
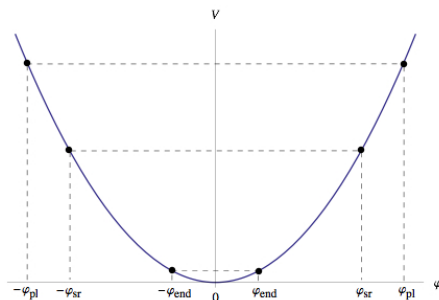
Main Message:

Dvali, Gomez '11, '12, '13

Not all systems are equal in terms of significant cumulative acquisition of microscopic corrections.

Interestingly, there are macroscopic systems for which such effects are of utmost importance; such as black holes, de Sitter and inflation.

Example of Inflation

$$V = \frac{1}{2}m^2\varphi^2$$

Standard : $\quad\quad\quad g_{\mu\nu} = \bar{g}_{\mu\nu}(t) + \hat{h}_{\mu\nu}, \quad\quad\quad \varphi = \bar{\varphi}(t) + \delta\hat{\varphi}$

Dvali $-$ Gomez : $g_{\mu\nu} = \eta_{\mu\nu} + \hat{h}_{\mu\nu}, \quad\quad\quad \varphi = \hat{\varphi}$

General Argument:
Dvali, Gomez, Zell '17

In a theory with dimensionless quantum coupling α, consider a state with large occupation number N.

Usually, it is possible to define a classical collective coupling αN that sets t_{cl}.

Taking into account that the same coupling leads to the re-scattering of the constituents, one can define the quantum time-scale

$$t_q = \frac{t_{cl}}{\alpha},$$

which sets the time required for the order 1 departure from the initial coherence.

From 2020 in this direction:

Pushing forward the validity of semi-classical treatment using 2PI-formalism. Kovtun and Zantedeschi 2003.10283, 2008.02187

Evolution of coherent states in QFT. LB and Zantedeschi 2011.11229

Evolution of black holes. Dvali, Eisemann, Michel and Zell 2006.00011

Quantum inconsistency of de Sitter spacetime. Dvali 2012.02133

In preparation

Otari Sakhelashvili, 3-forms in QFT.

Gia Dvali, Otari Sakhelashvili, Saturation of Unitarity and Entropy Bound.

LB, Giordano Cintia, Max Warkentin, Core Fragmentation in Superfluid Dark Matter Scenario.

Oleg Kaikov, Sebastian Zell, Thermalization in QFT.

Gia Dvali, Juan Valbuena, Interactions of Topological Defects.

Michael Zantedeschi, Florian Kühnel, Primordial Black Holes.

Gia Dvali, Andrei Kovtun, Entropy from Goldstone Bosons.

Manuel Ettengruber ..., Infrared Neutrino Physics.

Emmanouil Koutsangelas ..., Removing Cosmological Bound on Axions.

Thank you!