

Small nonassociative corrections to the SUSY generators and cosmological constant

V. Dzhunushaliev

IETP, Al-Farabi KazNU, Almaty, 050040, Kazakhstan

Dept. Theor. Phys., KazNU, Almaty, 050040, Kazakhstan

"The 12th International Workshop Dark Side of the Universe", Bergen, Norway, 2016

Dark energy models:

- Quintessence: dark energy is in the form of a time varying scalar field.
- K-essence: the modification of the scalar field canonical kinetic energy term.
- Chaplygin gas: eos $p = -A/\rho^\alpha$.
- $f(R)$ gravities.
- Brane cosmology models.
- ...
- Cosmological constant.

Cosmological constant - fundamental constant

All these models are dynamic in the sense that the present value of the cosmological constant Λ is explained in a dynamic way by using either some kind of matter or modified gravity. Another way is to postulate that Λ is indeed a fundamental constant. Following this way, it would be very interesting to understand what kind of physics is behind such approach.

From non-associativity to new fundamental constant

One can propose the idea that the cosmological constant Λ can be connected with the appearance of nonassociativity in physics. In this model, the constant Λ controls the smallness of NA effects in quantum physics: the dimensionless quantity $l_{Pl}^2 \Lambda \approx 10^{-120}$ shows where the NA effects may occur. It may happen on the huge scale $l_0 = 1/\sqrt{\Lambda} \approx 10^{26} \text{m}$ (that means that there exists a maximal length l_0)

How it can happen ? Main idea: the generalization of associative SUSY to non - associative SUSY leads to the appearance of a new fundamental constant that has the dimension cm^{-1} .

Mathematical preliminaries

In standard SUSY the operators $Q_{a,\dot{a}}$ and the momentum operator $P_\mu = -i\hbar\partial_\mu$ are connected by the expression

$$\{Q_a, Q_{\dot{a}}\} = 2\sigma_{a\dot{a}}^\mu P_\mu.$$

Let us recall the definition of an associator

$$[A, B, C] = (AB)C - A(BC),$$

Example of associator

$$[Q_a, Q_b, Q_c] = \frac{\hbar}{\ell_0} \zeta_1 (Q_a \epsilon_{bc} - Q_c \epsilon_{ab})$$

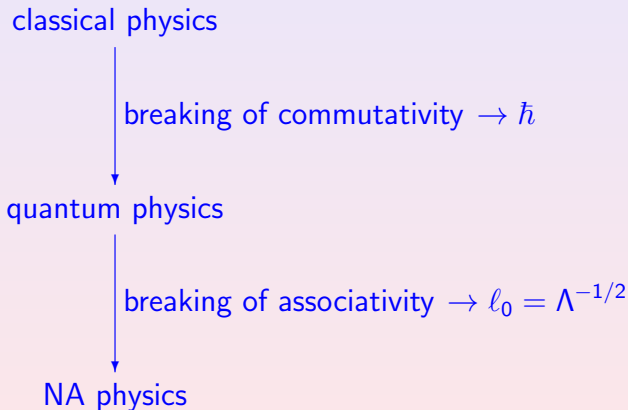
$$\ell_0 = \Lambda^{-1/2}$$

How it works ?

There exists a maximal length ℓ_0 or that in Nature there exists a minimal 4D scalar curvature (a unique Lorentz invariant quantity having the dimensions cm^{-2}): $R_{min} \approx \Lambda$. It immediately leads to a very simple explanation for the acceleration of the present Universe: the Universe reaches the minimally possible curvature and **has to stay in this state**.

From classical physics to NA physics

Physically, in this model the appearance of the Λ constant is connected with the breaking of non-associativity.



A few mathematical consequences

For small NA corrections:

$$\tilde{Q}_a = Q_a + \xi Q_{1,a} + \dots$$

where $\xi = (L_{PI}/\ell_0)^{1/3}$ is a small NA parameter.

A few mathematical consequences

A generalized uncertainty principle:

$$\left[x^\mu, \tilde{P}_\nu \right] = i\hbar \left[\delta_\nu^\mu + \frac{\xi}{P_0^2} (\delta_\nu^\mu P^2 + 2P^\mu P_\nu) \right]$$

q - deformed commutator:

$$\left[x^\mu, \tilde{P}_\nu \right]_q = qx^\mu \tilde{P}_\nu - \frac{1}{q} \tilde{P}_\nu x^\mu = i\hbar \delta_\nu^\mu.$$

- One can introduce non-associativity into SUSY.
- Breaking of non-associativity leads to a new fundamental constant with the dimension cm^{-1} that can be connected with the Λ constant.
- Small NA corrections appear in Heisenberg uncertainty principle: either as generalized uncertainty principle or as q - deformed commutator.

Thanks for your attention !