$O(d,d)$ symmetry in gravity

dedicated to Gabriele Veneziano

Krzysztof A. Meissner

FACULTY OF PHYSICS
UNIVERSITY OF WARSAW

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Common papers

1. K.A.Meissner and G.Veneziano, *Symmetries of cosmological superstring vacua*, Phys. Lett. **B267** (1991) 33-36.
2. K.A.Meissner and G.Veneziano, *Manifestly $O(d,d)$ invariant approach to space-time dependent string vacua*, Mod. Phys. Lett. **A6** (1991) 3397-3404.
3. M.Gasperini, M.Giovannini, K.A.Meissner and G.Veneziano, *Evolution of a string network in backgrounds with rolling horizons*, in *String gravity and physics at the Planck energy scale* (World Scientific, Singapore, 1995).
4. M.Gasperini, M.Giovannini, K.A.Meissner and G.Veneziano, *Evolution of strings in cosmological backgrounds*, Nucl. Phys **B49** (Proc.Supl.) (1996) 70-74.
5. A. Buonanno, K.A. Meissner, C. Ungarelli and G. Veneziano *Classical inhomogeneities in string cosmology*, Phys. Rev. **D57** (1998) 2543-2556
6. A. Buonanno, K.A. Meissner, C. Ungarelli and G. Veneziano, *Quantum inhomogeneities in string cosmology*, JHEP **01** (1998) 004.

Z_2 duality

- 'String inspired' action at the lowest order in α'

$$S_0 = \frac{1}{2\kappa}\int d^D x\sqrt{-g}e^{-\phi}\left(R + g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi - \frac{1}{12}H_{\mu\nu\rho}H^{\mu\nu\rho}\right),$$

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Gabriele noticed in April 1991 that if $B_{\mu\nu} = 0$, $g_{\mu\nu}$ is diagonal and depends only on time

$$g_{\mu\nu} = \mathrm{diag}(-1, a_i^2(t))$$

then the action is invariant under Z_2 transformation

$$a_i(t) \to a_i^{-1}(t), \quad \phi(t) \to \phi(t) - 2\sum \ln a_i(t)$$

G. Veneziano, Phys.Lett.B 265 (1991) 287

$O(d,d)$ symmetry

K.A.M., G. Veneziano, Phys.Lett.B 267 (1991) 33
K.A.M., G. Veneziano, Mod.Phys.Lett.A 6 (1991) 3397

- In June 1991 we noticed that if $B \neq 0$ the Z_2 symmetry can be generalized. Writing

$$g_{\mu\nu} = \begin{pmatrix} -1 & 0 \\ 0 & G(t) \end{pmatrix}, \quad B_{\mu\nu} = \begin{pmatrix} 0 & 0 \\ 0 & B(t) \end{pmatrix},$$

then introducing

$$M = \begin{pmatrix} G^{-1} & -G^{-1}B \\ BG^{-1} & G - BG^{-1}B \end{pmatrix}, \quad \eta = \begin{pmatrix} 0 & \mathbf{1} \\ \mathbf{1} & 0 \end{pmatrix}, \quad \Phi = \phi - \frac{1}{2}\ln\det G$$

we get

$$S = \int \mathrm{d}t\, \mathrm{e}^{-\Phi} \left[\Lambda + \dot{\Phi}^2 + \frac{1}{8}\mathrm{Tr}\left(\dot{M}\eta\dot{M}\eta \right) \right]$$

$O(d,d)$ symmetry

K.A.M., G. Veneziano, Phys.Lett.B 267 (1991) 33, Mod.Phys.Lett. A6 (1991) 3397

- S is explicitly invariant under $O(d,d)$

$$M \to \Omega^T \eta\, \Omega, \quad \Phi \to \Phi, \qquad \text{where} \quad \Omega^T \eta\, \Omega = \eta$$

the nontrivial part is given by $O(d,d)/(O(d) \times O(d))$.

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  K.A.M., Phys.Lett. B392 (1997) 298

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  N. Kaloper, K.A.M., Phys.Rev.D 56 (1997) 7940

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  N. Kaloper, K.A.M., Phys.Rev.D 56 (1997) 7940

- this symmetry (with classical sources) was the main component of the proposal of Pre-Big-Bang Cosmology

  M. Gasperini and G. Veneziano, Astropart. Phys. 1 (1993) 317

Fluctuations in PBB Cosmology

- the spectra of different fields were calculated in the picture:
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- flat EM spectrum especially interesting as being a possible seed of large-scale magnetic fields (the unsolved problem of cosmology)

Tanti auguri, Gabriele!