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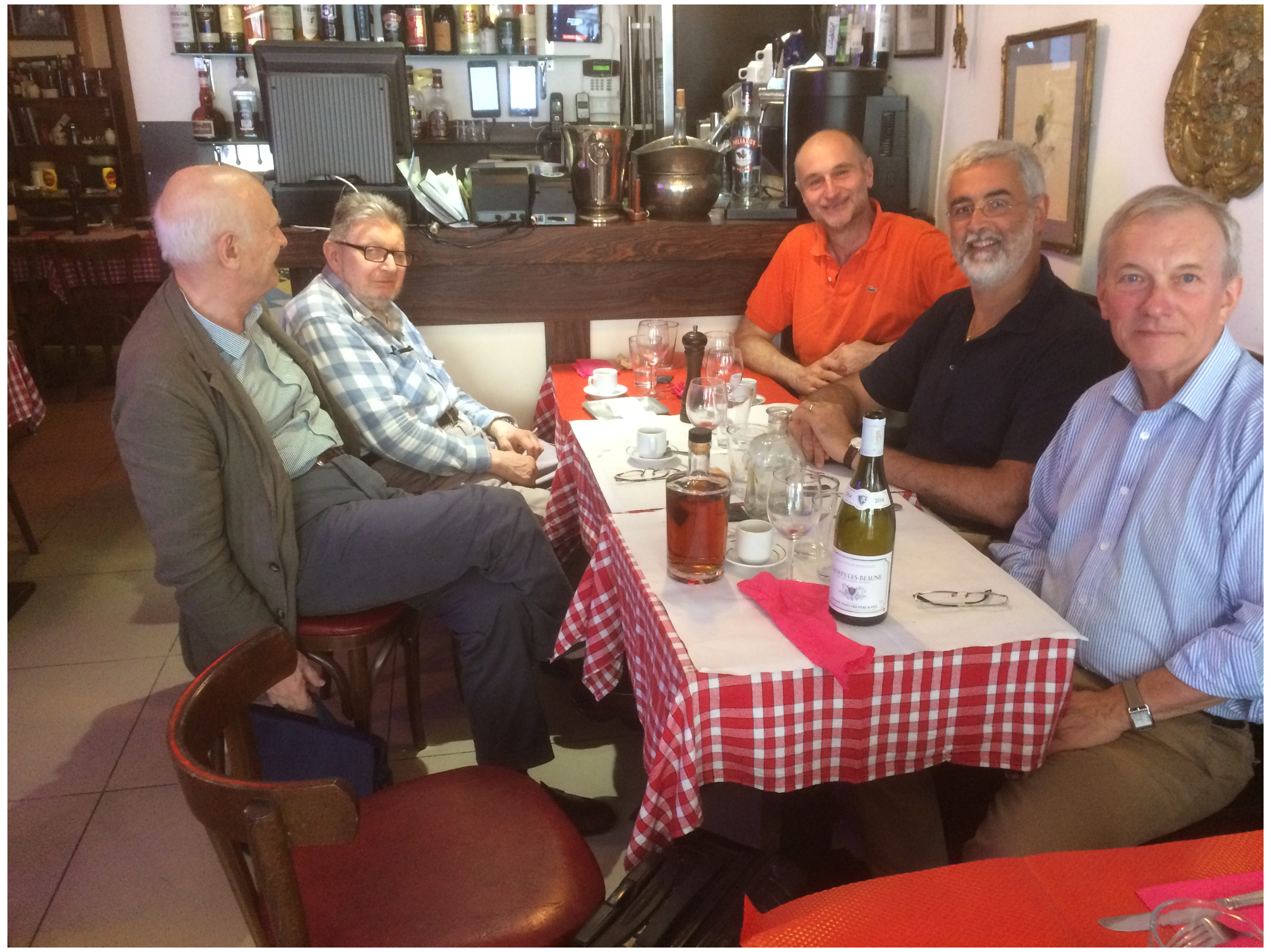

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Resolution of Hagedorn singularity in superstrings with gravito-magnetic fluxes

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(THERMAL) SUPERSYMMETRY BREAKING IN TYPE II SUPERSTRINGS

They afford a richer pattern than heterotic strings since

$$(-1)^{F_{\rm st}} = (-1)^{F_{\rm L}+F_{\rm R}}$$

We use this fact, to choose the thermal/Scherk-Schwarz breaking

$$\mathbb{Z}_2 \times \mathbb{Z}_2$$

$$(-1)^{F_{\rm L}}\,\delta_1 \qquad (-1)^{F_{\rm R}}\,\delta_2$$

($\delta_{1,2}$ shifts along two different directions)

(Thermal) Supersymmetry Breaking in Type II Superstrings

$$\mathcal{Z} = \Big[V_8\, \mathit{\Gamma}^{(1)}_{m,2n} - S_8\; \mathit{\Gamma}^{(1)}_{m+\frac{1}{2},2n} + O_8\, \mathit{\Gamma}^{(1)}_{m+\frac{1}{2},2n+1} - C_8\, \mathit{\Gamma}^{(1)}_{m,2n+1} \Big]$$
$$\times \Big[\bar{V}_8\, \mathit{\Gamma}^{(2)}_{m,2n} - \bar{S}_8\; \mathit{\Gamma}^{(2)}_{m+\frac{1}{2},2n} + \bar{O}_8\, \mathit{\Gamma}^{(2)}_{m+\frac{1}{2},2n+1} - \bar{C}_8\, \mathit{\Gamma}^{(2)}_{m,2n+1} \Big]$$

All fermions and RR states are massive, and tachyons are absent

$$2\, m^2_{O\bar{O}} = \left(\frac{1}{\sqrt{2}R_1} - \sqrt{2}R_1 \right)^2 + \left(\frac{1}{\sqrt{2}R_2} - \sqrt{2}R_2 \right)^2$$

The model enjoys T-duality: $\sqrt{2}R \to 1/\sqrt{2}R$

Thermal Interpretation

In the Lagrangian representation the shift

$$\tilde{m}_1 \to \tilde{m}_1 + \tilde{m}_0\,, \qquad n_1 \to n_1 + n_0$$

results into the GSO phase

$$(-1)^{\tilde{m}_0(a+\bar{a})+n_0(b+\bar{b})}\,(-1)^{\tilde{m}_1\bar{a}+n_1\bar{b}+\tilde{m}_1 n_1}$$

canonical temperature

breaks $\mathcal{N}=(4,4) \to \mathcal{N}=(4,0)$

$$\mathcal{Z}(\beta) = \mathrm{tr}\; e^{-\beta H} e^{2\pi i (G Q_+ - B Q_-)}\Big|_{G=1,B=\frac{1}{2}}$$

Thermal Interpretation

The complete partition function for the *N*=(4,0) theory reads then

$$\mathcal{Z}(\beta) = \mathrm{tr}\ e^{-\beta H} e^{2\pi i (G Q_+ - B Q_-)}\Big|_{G=1, B=\frac{1}{2}}$$

It is free of Hagedorn instabilities, and enjoys a temperature duality

$$\mathcal{Z}(T/T_{\mathrm{H}}) = \mathcal{Z}(T_{\mathrm{H}}/T)$$

(Thermal) Supersymmetry Breaking in Type II Superstrings

Something interesting happens at the self-dual point $\sqrt{2}R_{1,2} = 1$

$$\mathcal{Z} = \Big[V_8\, \Gamma^{(1)}_{m,2n} - S_8\; \Gamma^{(1)}_{m+\frac{1}{2},2n} + O_8\, \Gamma^{(1)}_{m+\frac{1}{2},2n+1} - C_8\, \Gamma^{(1)}_{m,2n+1} \Big]$$
$$\times \Big[\bar{V}_8\, \Gamma^{(2)}_{m,2n} - \bar{S}_8\; \Gamma^{(2)}_{m+\frac{1}{2},2n} + \bar{O}_8\, \Gamma^{(2)}_{m+\frac{1}{2},2n+1} - \bar{C}_8\, \Gamma^{(2)}_{m,2n+1} \Big]$$

The vectors $V\bar{O}$ and $O\bar{V}$ are now level matched

and the “graviphotons” have the enhanced gauge symmetry

$$SO(4)_{\rm L} \times SO(4)_{\rm R}$$

(This is possible because of the asymmetry nature of the construction)

Adding O-planes and D-branes

Something ***more*** interesting happens if we orientifold this model

$$\mathcal{A} \supset N^2 \sum_{m,n} \left[(V_6 O_2 + O_6 V_2) q^{\frac{1}{2}\left(\frac{m}{\sqrt{2}R}\right)^2 + \frac{1}{2}(n\sqrt{2}R)^2} + O_6 O_2 q^{\frac{1}{2}\left(\frac{m+1/2}{\sqrt{2}R}\right)^2 + \frac{1}{2}((n+1/2)\sqrt{2}R)^2} \right]$$

$$\mathcal{M} \supset -N \sum_{m,n} \left[(V_6 O_2 - O_6 V_2)(-1)^{m+n} q^{\frac{1}{2}\left(\frac{m}{\sqrt{2}R}\right)^2 + \frac{1}{2}(n\sqrt{2}R)^2} - O_6 O_2 q^{\frac{1}{2}\left(\frac{m+1/2}{\sqrt{2}R}\right)^2 + \frac{1}{2}((n+1/2)\sqrt{2}R)^2} \right]$$

At the self-dual point, the scalars living on the D-branes are charged with respect to the (diagonal) closed-string gauge group $SO(4)$ **!**

$$(\mathbf{6}, \mathbf{136}) \quad \text{of} \quad SO(4)_{\text{closed}} \times SO(16)_{\text{open}}$$

Never seen before ... or after

GOOD BYE COSTAS AND EUGENE