Supersymmetry breaking in moduli-mixing racetrack model

YITP, Kyoto University Hiroyuki Abe
E-mail: abe@yukawa.kyoto-u.ac.jp

In this talk we show some structures of moduli stabilization and SUSY breaking in so-called racetrack model with double gaugino condensations where gauge couplings are given by more than one modulus field[1] (two moduli in practice). The 4D effective supergravity (within type IIB $O3/O7$ framework for concreteness) is given by the Kähler potential and superpotential

$$K = -n_T \ln(T + \bar{T}) - n_S \ln(S + \bar{S}), \quad W = Ae^{-af_a} - Be^{-bf_b}, \quad f_{a,b} = m_{a,b}S + w_{a,b}T, \tag{1}$$

where S and T are the dilaton and Kähler (size) modulus respectively, and $m_{a,b}$, $w_{a,b}$ are respectively the magnetic flux and winding number of the D-brane, where the gaugino condensation occurs. We assume that the existence of three-form flux (in ten-dimensions) stabilize the complex structure (shape) moduli $\langle U \rangle \sim 1$ around the Planck scale. Note that, due to the flux, there is a significantly warped region in the Calabi-Yau (CY) space.

If the same three-form flux induces a SUSY mass like $W \sim SU$, the dilaton is also stabilized $\langle S \rangle \sim 1$ at the same scale. In this case we replace S in Eq. (1) by its VEV, $\langle S \rangle$. Then the effective superpotential becomes $W = A'e^{-aw_aT} - B'e^{-bw_bT}$, which is in the same form as the racetrack model with single modulus, but the coefficients are exponentially suppressed $A' = Ae^{-am_a\langle S \rangle}$, $B' = Be^{-bm_b\langle S \rangle}$ where $a = 8\pi^2/N_a$ and $b = 8\pi^2/N_b$ for $SU(N_{a,b})$ gaugino condensation. The minimum of the scalar potential corresponds to a SUSY AdS$_4$ local minimum with negative vacuum energy and $a\langle \mathrm{Re}\, T \rangle = aT_{SUSY} \sim \ln(M_{Pl}/m_{3/2})$, where $m_{3/2} \approx 10^{-14} M_{Pl}$ is the gravitino mass. To be phenomenologically viable, we uplift the vacuum energy by introducing anti $D3$-branes at the top of warped region in the CY space. Then the SUSY is broken due to the slight shift $\delta T = (T_{SUSY} - \langle T \rangle) \ll T_{SUSY}$ caused by an additional potential energy of $\overline{D3}$s. In this case, the ratio between the VEV of auxiliary component in the chiral compensator C, $F^C \sim m_{3/2}$, and one in T, F^T, is given by ($w_a = 0$ for simplicity) $\alpha = \frac{F^C}{\ln(M_{Pl}/m_{3/2})} \frac{T+\bar{T}}{F^T} \simeq (1 + m_b\langle S \rangle / w_b T_{SUSY})^{-1}$. This corresponds to the ratio between the so-called anomaly mediation and the modulus mediation for the visible sector SUSY breaking. We find that α varies in a wide range with various magnetic flux $m_{a,b}$, compared to $\alpha \sim 1$ without the magnetic flux.

On the other hand, if the three-form flux does not contain the SUSY mass term $W \sim SU$, the dilaton remains as a light modulus as well as T in Eq. (1). A careful analysis of (1) shows that a SUSY AdS$_4$ stationary point of the scalar potential corresponds to a saddle point, and we have a SUSY breaking AdS$_4$ local minimum close to the SUSY point in this case. By uplifting this local minimum, we can obtain Minkowski minimum but with modulus-dominated SUSY breaking $\alpha \ll 1$. This is because SUSY is broken before uplifting.

[1]This talk is based on works in collaboration with T. Higaki and T. Kobayashi