Moduli Stabilisation and Axion Inflation with Non-geometric Fluxes

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arXiv:1409.7075 [Ralph Blumenhagen, DH, Erik Plauschinn]
arXiv:1503.xxxxx [Ralph Blumenhagen, Anamaría Font, Michael Fuchs, DH, Erik Plauschinn, Yuta Sekiguchi, Florian Wolf]

string theory:

a lots of scalar fields

→ almost none of these observed

→ can solve open questions

e.g. QCD axion, dark matter, inflation, ...

Why are there so many scalar fields?

- type II B (A) string theory contains p-forms C_p with p even (odd)
- dilaton $\phi \rightarrow$ string coupling $e^{-\phi}$
- deformations of extra dimensions parametrised by *moduli*

  Kähler moduli $\rightarrow$ volume of internal space

  complex structure moduli $\rightarrow$ shape of internal space
- open string moduli, ... $\rightarrow$ not considered here

How do we explain their absence in observations

→ too heavy to be observed

→ we need a mechanism to make them heavy

→ moduli stabilisation e.g. via coupling to fluxes

in type IIB:

$$\text{fluxes } F_3 = dC_2 \text{ and } H_3 = dB_2$$

Use one of those moduli fields as inflaton

$\rightarrow$ leave one modulus light and use it as inflaton

$\rightarrow$ effective potential for inflaton

$\rightarrow$ inflaton is axionic

moduli stabilisation scheme behind axion monodromy inflation

axion monodromy inflaton

large field inflation $\Delta\phi > M_p$

- shift symmetry $\rightarrow$ axion
- symmetry broken in controlled way $\rightarrow$ monodromy

string theory contains some axions

- C_p Ramond Ramond fields
- axionic part of complex structure moduli in the large complex structure limit

- type IIB: fluxes stabilise complex structure moduli and axio-dilaton

$$W = \int \Omega \wedge (S\, H_3 + F_3)$$

with

Ω depends on complex structure moduli

S axio-dilaton $S = e^{-\phi} + i\, C_0$

- Kähler moduli $T = \tau + i\, C_4$ stabilised by corrections

e.g. non-perturbative corrections to superpotential $W \sim e^{-aT}$

scalar potential

$$V_F = \frac{M_{\mathrm{Pl}}^4}{4\pi}\, e^K \left(K^{I\bar{J}} D_I W D_{\bar{J}} \overline{W} - 3 \left| W \right|^2 \right)$$

with

Kähler potential

$$K = -\log\left(-i \int_{\mathcal{M}} \Omega \wedge \overline{\Omega} \right) - \log\left(S + \overline{S} \right) - 2 \log \mathcal{V}$$

- stabilise all saxions, while unstabilised axions are allowed
- we are interested in non-susy minima

Procedure

1. stabilise complex structure moduli and the axio-dilaton except the axionic inflaton
2. turn on small fluxes to stabilise the inflaton

   tune moduli masses bigger than axion mass

   $$W = \lambda\, W_{mod} + W_{ax}$$

   with $\lambda >> 1$

   axion mass not tunable to be small!
3. stabilise Kähler moduli s.t. $M_T > M_{ax}$

Kähler moduli stabilisation via g_s-, α'- and non-perturbative corrections

$$\Rightarrow M_T < M_{rest}$$

tree level Kähler moduli stabilisation

$$\begin{aligned} W = & -\quad\ \left(\mathfrak{f}_\lambda\, X^\lambda - \tilde{\mathfrak{f}}^\lambda\, F_\lambda \right) \\ & + i S\, \left(h_\lambda\, X^\lambda - \tilde{h}^\lambda\, F_\lambda \right) \\ & - i G^a \left(f_{\lambda a}\, X^\lambda - \tilde{f}^\lambda{}_a\, F_\lambda \right) \\ & + i T_\alpha \left(q_\lambda{}^\alpha\, X^\lambda - \tilde{q}^{\lambda\alpha}\, F_\lambda \right) \end{aligned}$$

$\mathfrak{f}$ RR-flux

h H-flux

f geometric flux

q non-geometric Q-flux

[Shelton, Taylor, Wecht], [Grana, Louis, Waldram]

non-geometric fluxes stabilise h^{11}_+ moduli
geometric fluxes stabilise h^{11}_- moduli

results

- set of vacua with parametrical control over the vacuum expectation values
- many massless axions which can be stabilised via

$$W = \lambda \, W_{mod} + W_{ax}$$

  framework to realise F-term axion monodromy inflation
- high scale supersymmetry

problems

- tachyons if we consider more moduli
- vacua AdS and uplift mechanism to dS not clear
- uplift to string theory not clear
- hierarchy of masses $M_{\mathrm{Pl}} > M_{\mathrm{s}} > M_{\mathrm{KK}} > M_{\mathrm{mod}} > H_{\mathrm{inf}} > M_{\Theta}$ hard to achieve