String Phenomenology: Non-perturbative effects

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String theory: Only perturbation series can be defined

$$\mathcal{A}(gg \to gg) = g_s \mathcal{A}_1 + g_s^2 \mathcal{A}_2 + \dots \tag{1}$$

Like in QFT, but there is no path integral!

Perturbation theory does not always work

$\to$ Non perturbative effects $\sim \exp(-1/g_s)$

Motivation: Why study non-perturbative effects?

- Ingredient in model building:
  - Neutrino masses
  - positive vacuum energy (KKLT)
- Hints on nature of string theory

D-brane instantons:

How to compute their effects?

- Use open string theory
- Analogy to field theory

Partial success: Some methods available, reasonable results, many open problems