Project: T-branes in F-theory and 3d supersymmetric field theories

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When quantum gravity effects are dominant, classical geometry, intended as a smooth manifold structure, breaks down. The simplest situation in which this occurs is when the manifold develops a singularity. One can study the resulting geometry at the quantum level, by considering the theory of strings propagating in such a singular geometry.
Singularities in string theory can be approached by the geometric engineering paradigm: One defines type IIA on the singularity, and considers the effective field theory arising from the supergravity zero modes on this space, supplemented by the light degrees of freedom created by D2-branes wrapping the vanishing cycles. This setup is dual to M-theory compactified on a circle times the same space, with M2-branes replacing the D2-branes. If the singular space is an elliptic fibration, taking the limit of vanishing size of the fiber gives F-theory [1]. F-theory is a modern tool that provides a good description of IIB string theory, in the non-perturbative regime, when D7-branes are present. Gauge groups and charged matter are encoded in the singularity structure.

A singular space in F-theory can support a so called T-brane [2]. However, contrary to other 7-brane configurations, the geometry of the elliptic fibration is not enough to detect the presence of this object. To define what a T-brane is from the M-theory/F-theory point of view, we hence proposed to probe the singularity by an M2-brane [3,4]. The T-brane deforms the supersymmetric three-dimensional theory living on this membrane by the addition of a monopole operator in the superpotential. In order to understand how the probe theory is modified, one needs to apply 3d dualities that map the monopole deformation to a standard Lagrangian deformation. The study of these dualities is of interest by itself. Only simple configurations have been analyzed so far, but the most interesting ones, relevant also for the phenomenology of F-theory compactifications, are still to be studied. This is the aim of our project. In order to understand which theory lives on the probe membrane, the knowledge of the quiver associated with the singularity is necessary. This connects the topics of the project to the NCCR (Non Commutative Crepant Resolution) approach to singularities.

REFS
[1] For a review see T. Weigand, TASI Lectures on F-theory, arXiv:1806.01854.
[2] S. Cecotti, C. Cordova, J. J. Heckman and C. Vafa, T-Branes and Monodromy, JHEP 07 (2011) 030.
[3] A. Collinucci, S. Giacomelli, R. Savelli and R. Valandro, T-branes through 3d mirror symmetry, JHEP 07 (2016) 093.
[4] A. Collinucci, S. Giacomelli, and R. Valandro, T-branes, monopoles and S-duality, JHEP 10 (2017) 113.