

# Workshop: Matrix Factorizations in Mathematics and Physics

Events for:  
Monday, June 12th - Friday, June 16th

## Monday, June 12th

9:00am **David Berenstein - SCGP 102**

**Title:** D-branes, categories and super-potential algebras

**Abstract:** I will describe some of the physics intuition that gives rise to a structure of categories of D-branes. I will then concentrate on the structure of the category of "point-like objects" near a singularity. This will use some examples of orbifolds and I will also show the concept of discrete torsion. I will then specialize further to situations that arise for the point-like branes that probe a Calabi-Yau singularity and use the physics intuition to show that one gets the notion of a "super potential algebra" and some of the properties they have for orbifolds.

10:00am **Break - SCGP Cafe**

10:30am **David Berenstein - SCGP 102**

**Title:** Regular super potential algebras

**Abstract:** I will show some examples of super potential algebras, some will be orbifolds and some that do not correspond to orbifold singularities. I will describe how one expects the corresponding super potential algebras to be regular. And I will give some techniques for proving such regularity. I will also talk about Seiberg -dualities and how they define equivalence classes of algebras. (The equivalence class is a Derived equivalence of categories)

11:30am **Lunch - SCGP Cafe**

1:00pm **Johannes Walcher - SCGP 102**

**Title:** Extended Frobenius manifolds and the Kapustin-Li formula

2:15pm **Antonella Grassi - SCGP 102**

**Title:** Terminal singularities of Calabi-Yau threefolds, Milnor numbers and applications to physics

3:30pm **Tea - SCGP Lobby**

## Tuesday, June 13th

9:00am **Matthew Ballard - SCGP 102**

**Title:** Kernels for Orlov's theorem

10:00am **Break - SCGP Cafe**

10:30am **Ludmil Katzarkov - SCGP 102**

**Title:** Categories and Filtrations

**Abstract:** In this talk we will introduce a new notion - filtration of iterated logs. We will consider possible application of this notion to classical questions in Geometry.

11:30am **Lunch - SCGP Cafe**

1:00pm **SCGP Weekly Talk: David Morrison - SCGP 102**

**Title:** Matrix factorizations in physics: a mathematical perspective

**Abstract:** Matrix factorizations were introduced into mathematics in 1980, and found their first applications to physics in 2003. I will explain the nature of these applications from a mathematical perspective.

2:15pm **Kentaro Hori - SCGP 102**

**Title:** An introduction to the hemisphere partition function

**Abstract:** I will talk about the hemisphere partition function of 2d (2,2) supersymmetric field theories and some of its applications, such as equivalences of categories, RG flow involving branes, and geometric/Landau-Ginzburg expansions.

3:30pm **Tea - SCGP Lobby**

## Wednesday, June 14th

9:00am **Irena Peeva - SCGP 102**

**Title:** Matrix factorizations and free resolutions

**Abstract:** Matrix factorizations can be interpreted as giving the minimal free resolutions of maximal Cohen-Macaulay modules ("high" syzygies) over a hypersurface ring both as a module over the ambient ring and as a module over the hypersurface. The talk will first provide background on free resolutions, and then introduce the theory of higher matrix factorizations which gives the analogous results for high syzygies over complete intersections. All this is joint work with David Eisenbud, who will deliver a second part of the talk.

10:15am **David Eisenbud - SCGP 102**

**Title:** Layered Resolutions

**Abstract:** Layered resolutions include the resolutions derived from higher matrix factorizations that were described in the preceding talk. They are not defined equationally, but they are conceptually simpler as well as being more general. I will explain the necessary background -- the Auslander-Buchweitz theory of Cohen-Macaulay approximations -- and also the construction of layered resolutions. This is joint work with Irena Peeva.

11:15am **Break - SCGP Cafe**

11:45am **David Morrison - SCGP 102**

**Title:** Matrix factorizations in physics: a mathematical perspective II

**Abstract:** Matrix factorizations were introduced into mathematics in 1980, and found their first applications to physics in 2003. I will explain the nature of these applications from a mathematical perspective.

12:45pm **Lunch - SCGP Cafe**

3:30pm **Tea - SCGP Lobby**

**Thursday, June 15th**

9:00am **Andres Collinucci - SCGP 102**

**Title:** Monopole operators, going beyond the Auslander-Reiten quiver

10:00am **Break - SCGP Cafe**

10:30am **Hailong Dao - SCGP 102**

**Title:** Some categorical aspects of matrix factorizations

**Abstract:** The category of matrix factorizations can be identified with certain category of maximal Cohen-Macaulay modules over the corresponding hypersurface (or complete intersections, as in the recent work of Eisenbud-Peeva). This point of view have been exploited heavily, and is still yielding surprising insights. In this talk I will survey some recent works in this direction. One part will focus on a certain pairing on the MCM modules which has interesting connections to K-theory and other cohomology theories. Another part will discuss Avramov-Buchweitz work on support varieties and a recent result that allows us to associate to certain tensor products of matrix factorization the geometric joint of the corresponding varieties.

11:30am **Lunch - SCGP Cafe**

1:00pm **David Morrison - SCGP 102**

**Title:** Matrix factorizations in physics: a mathematical perspective III

**Abstract:** Matrix factorizations were introduced into mathematics in 1980, and found their first applications to physics in 2003. I will explain the nature of these applications from a mathematical perspective.

2:15pm **Johanna Knapp - SCGP 102**

**Title:** Deformation theory of matrix factorizations and physics applications

3:30pm **Tea - SCGP Lobby**

**Friday, June 16th**

9:00am **David Favero - SCGP 102**

**Title:** Crepant Categorical Resolutions and a Toric Orlov Theorem

**Abstract:** Desingularizing a variety is, of course, not unique. For example, there can be many crepant resolutions of a given space. However, in their pioneering work on derived categories, Bondal and Orlov conjectured that all such resolutions have equivalent derived categories. In this way, categorically resolving singularities may have some nicer properties than classical resolutions. I will discuss how a toric version of Orlov's theorem provides a method of obtaining categorical crepant resolutions that can be given explicit geometric realizations as Landau-Ginzburg models. We will focus on some motivating examples such as Kuznetsov's categorical crepant resolution of the K3 category inside a singular cubic 4-fold. This is joint work with T. Kelly.

10:15am **Raffaele Savelli - SCGP 102**

**Title:** F-theory on Singular Spaces

**Abstract:** F-theory is a strong coupling formulation of Type IIB string theory which unifies gravitational and gauge theory data of 7-branes in the geometry of elliptic fibrations. In all situations of interest such fibrations are singular spaces, and, in order to describe the low-energy physics, one typically removes the singularities either via resolutions or deformations. On the contrary, in this talk, I will show how Matrix Factorizations allow us to access part of the physical data while working on the singular spaces directly. Besides correctly reproducing known results, this treatment enables us to explore certain supersymmetric string vacua which are invisible in the smooth phase.

11:15am **Break - SCGP Cafe**

11:45am **Ragnar Buchweitz - SCGP 102**

**Title:** Matrix Factorizations and Tilting Objects

**Abstract:** Whenever a triangulated category admits a tilting object  $T$ , it identifies with the derived category of  $E = \text{End}(T)$ . How does one get back from that derived category to the original one? We describe an algorithm for the case that  $E$  is an artinian algebra of finite global dimension. As an example, we use this to identify all matrix factorizations of  $y^d - x^d$  for  $d \neq 2$ , thus, answering a question raised several years ago by physicists. We will also discuss the case of cubic hypersurfaces, where some intriguing representation theoretic problems occur.

12:45pm **Lunch - SCGP Cafe**

3:30pm **Tea - SCGP Comm Room 515**