LIST OF PUBLICATIONS AND PREPRINTS

MICHAIL SAVVAS

Publications

- *Generalized Donaldson-Thomas Invariants via Kirwan Blowups* (joint with Y.-H. Kiem, J. Li).
  Accepted for publication in: ***Journal of Differential Geometry***.
  Available at: `arXiv:1712.02544`.

  Abstract: We develop a virtual cycle theoretic approach towards generalized Donaldson-Thomas theory of Calabi-Yau threefolds. Let $\mathcal{M}$ be the moduli stack of Gieseker semistable sheaves of fixed topological type on a Calabi-Yau threefold W.

  We construct an associated Deligne-Mumford stack $\widetilde{\mathcal{M}}$ with an induced semi-perfect obstruction theory of virtual dimension zero and define the generalized Donaldson-Thomas invariant of W via Kirwan blowups to be the degree of the virtual cycle $[\widetilde{\mathcal{M}}]^{\mathrm{vir}}$. We show that it is invariant under deformations of the complex structure of W.

- *Cosection localization and vanishing for virtual fundamental classes of d-manifolds*.
  Published in: ***Advances in Mathematics****, 398 (2022), Paper No. 108232, 34.*

  Abstract: We establish cosection localization and vanishing results for virtual fundamental classes of derived manifolds, combining the theory of derived differential geometry by Joyce with the theory of cosection localization by Kiem-Li. As an application, we show that the stable pair invariants of hyperkähler fourfolds, defined by Cao-Maulik-Toda, are zero.

- *K-Theoretic Generalized Donaldson-Thomas Invariants* (joint with Y.-H. Kiem).
  Published in: ***International Mathematics Research Notices IMRN****, (2022), pp. 2123–2158.*

  Abstract: We introduce the notion of almost perfect obstruction theory on a Deligne-Mumford stack and show that stacks with almost perfect obstruction theories have virtual structure sheaves which are deformation invariant. The main components in the construction are an induced embedding of the coarse moduli sheaf of the intrinsic normal cone into the associated obstruction sheaf stack and the construction of a K-theoretic Gysin map for sheaf stacks. We show that many stacks of interest admit almost perfect obstruction theories. As a result, we are able to define virtual structure sheaves and K-theoretic classical and generalized Donaldson-Thomas invariants of sheaves and complexes on Calabi-Yau threefolds.

- *Localizing Virtual Structure Sheaves for Almost Perfect Obstruction Theories* (joint with Y.-H. Kiem).
  Published in: ***Forum of Mathematics, Sigma****, Volume 8, 2020, e61.*

  Abstract: Almost perfect obstruction theories were introduced in an earlier paper by the authors as the appropriate notion in order to define virtual structure sheaves and K-theoretic invariants for many moduli stacks of interest, including K-theoretic Donaldson-Thomas invariants of sheaves and complexes on Calabi-Yau threefolds. The construction of virtual structure sheaves is based on the K-theory and Gysin maps of sheaf stacks.

  In this paper, we generalize the virtual torus localization and cosection localization formulas and their combination to the setting of almost perfect obstruction theory. To this end, we further investigate the K-theory of sheaf stacks and its functoriality properties. As applications of

the localization formulas, we establish a K-theoretic wall crossing formula for simple $\mathbb{C}^*$-wall crossings and define K-theoretic invariants refining the Jiang-Thomas virtual signed Euler characteristics.

- *Intrinsic Stabilizer Reduction and Generalized Donaldson-Thomas Invariants*.
  Published in: ***Journal of the Institute of Mathematics of Jussieu****, 22(4), 1987-2025.*.
  Available at: `arXiv:2005.13768`.

  Abstract: Let σ be a stability condition on the bounded derived category $D^b(\mathrm{Coh}W)$ of a Calabi-Yau threefold W and $\mathcal{M}$ a moduli stack parametrizing σ-semistable objects of fixed topological type. We define generalized Donaldson-Thomas invariants which act as virtual counts of objects in $\mathcal{M}$, fully generalizing the approach introduced by Kiem, Li and the author in the case of semistable sheaves.

  We construct an associated proper Deligne-Mumford stack $\widetilde{\mathcal{M}}^{\mathbb{C}^*}$, called the $\mathbb{C}^*$-rigidified intrinsic stabilizer reduction of $\mathcal{M}$, with an induced semi-perfect obstruction theory of virtual dimension zero, and define the generalized Donaldson-Thomas invariant via Kirwan blowups to be the degree of the associated virtual cycle $[\widetilde{\mathcal{M}}]^{\mathrm{vir}} \in A_0(\widetilde{\mathcal{M}})$. This stays invariant under deformations of the complex structure of W. Applications include Bridgeland stability, polynomial stability, Gieseker and slope stability.

- *The d-critical Structure on the Quot Scheme of Points of a Calabi-Yau 3-fold* (joint with A. Ricolfi).
  Accepted for publication in: ***Communications in Contemporary Mathematics***.
  Available at: `arXiv:2106.16133`.

  Abstract: The Artin stack $\mathcal{M}_n$ of 0-dimensional sheaves of length n on $\mathbb{A}^3$ carries two natural d-critical structures in the sense of Joyce. One comes from its description as a quotient stack $[\mathrm{Crit}(f_n)/\mathrm{GL}_n]$, another comes from derived deformation theory of sheaves. We show that these d-critical structures agree. We use this result to prove the analogous statement for the Quot scheme of points $\mathrm{Quot}_{\mathbb{A}^3}(\mathcal{O}^{\oplus r}, n) = \mathrm{Crit}(f_{r,n})$, which is a global critical locus for every $r > 0$, and also carries a derived-in-flavour d-critical structure besides the one induced by the potential $f_{r,n}$. Again, we show these two d-critical structures agree. Moreover, we prove that they locally model the d-critical structure on $\mathrm{Quot}_X(F, n)$, where F is a locally free sheaf of rank r on a projective Calabi-Yau 3-fold X.

  Finally, we prove that the perfect obstruction theory on $\mathrm{Hilb}^n\,\mathbb{A}^3 = \mathrm{Crit}(f_{1,n})$ induced by the Atiyah class of the universal ideal agrees with the *critical* obstruction theory induced by the Hessian of the potential $f_{1,n}$.

- *Virtual Riemann-Roch Theorems for Almost Perfect Obstruction Theories*.
  Accepted for publication in: ***manuscripta mathematica***.
  Available at: `arXiv:2207.14397`.

  Abstract: This is the third in a series of works devoted to constructing virtual structure sheaves and K-theoretic invariants in moduli theory. The central objects of study are almost perfect obstruction theories, introduced by Y.-H. Kiem and the author as the appropriate notion in order to define invariants in K-theory for many moduli stacks of interest, including generalized K-theoretic Donaldson-Thomas invariants.

  In this paper, we prove virtual Riemann-Roch theorems in the setting of almost perfect obstruction theory in both the non-equivariant and equivariant cases, including cosection localized versions. These generalize and remove technical assumptions from the virtual Riemann-Roch theorems of Fantechi-Göttsche and Ravi-Sreedhar. The main technical ingredients are a treatment of the equivariant K-theory and equivariant Gysin map of sheaf stacks and a formula for the virtual Todd class.

- *Shutout Games on Graphs* (joint with A. Cioba).
  Published in: ***Mathematika****, volume 61 (2015), issue 03, pp. 523-530.*

Abstract: Two players take it in turn to claim edges from a graph G. The first player ("Maker") wins if at any point they have claimed s edges at a vertex without the second player ("Breaker") having claimed a single edge at that vertex. If, by the end of play, this does not occur we say that Breaker wins. Our main aim is to show that for every s there is a graph G in which Maker has a winning strategy.

Preprints

- *Stabilizer Reduction for Derived Stacks and Applications to Sheaf-Theoretic Invariants* (joint with J. Hekking and D. Rydh).
  Available at: `arXiv:2209.15039`.

Abstract: We construct a canonical stabilizer reduction $\widetilde{X}$ for any derived 1-algebraic stack X over $\mathbb{C}$ as a sequence of derived Kirwan blow-ups, under mild natural conditions that include the existence of a good moduli space for the classical truncation X_{cl}. Our construction naturally generalizes Kirwan's classical partial desingularization algorithm to the context of derived algebraic geometry.

We prove that $\widetilde{X}$ is a natural derived enhancement of the intrinsic stabilizer reduction constructed by Kiem, Li and the third author. Moreover, if X is (-1)-shifted symplectic, we show that the semi-perfect and almost perfect obstruction theory and their induced virtual fundamental cycle and virtual structure sheaf of $\widetilde{X}_{\mathrm{cl}}$, constructed by the same authors, are naturally induced by $\widetilde{X}$ and its derived tangent complex. As a corollary, we give a fully derived perspective on generalized Donaldson-Thomas invariants of Calabi-Yau threefolds and define new generalized Vafa-Witten invariants for surfaces via Kirwan blow-ups.

- *Good Moduli Spaces in Derived Algebraic Geometry* (joint with E. Ahlqvist, J. Hekking and M. Pernice).
  Available `here`.

Abstract: We develop a theory of good moduli spaces for derived Artin stacks, which naturally generalizes the classical theory of good moduli spaces introduced by Alper. As such, many of the fundamental results and properties regarding good moduli spaces for classical Artin stacks carry over to the derived context. In fact, under natural assumptions often satisfied in practice, we show that the derived theory essentially reduces to the classical theory. As applications, we establish derived versions of the étale slice theorem for stacks and the partial desingularization procedure of good moduli spaces.

- *Cosection Localization for D-Manifolds and (-2)-Shifted Symplectic Derived Schemes, Revisited*.
  Available at: `arXiv:2309.03066`.

Abstract: This is a continuation of prior work of the author on cosection localization for d-manifolds. We construct reduced virtual fundamental classes for derived manifolds with surjective cosections and cosection localized virtual fundamental classes for (-2)-shifted symplectic derived schemes in larger generality. Moreover, using recent results of Oh–Thomas, we show that the algebraic and differential geometric constructions of reduced and cosection localized virtual fundamental classes of (-2)-shifted symplectic derived schemes yield the same result in homology. We obtain applications towards the construction and integrality of reduced invariants in Donaldson–Thomas theory of Calabi–Yau fourfolds.

- *Categorical Semantics of Compositional Reinforcement Learning* (joint with G. Bakirtzis and U. Topcu).
  Available at: `arXiv:2208.13687`.

Abstract: Reinforcement learning (RL) often requires decomposing a problem into subtasks and composing learned behaviors on these tasks. Compositionality in RL has the potential to create modular subtask units that interface with other system capabilities. However, generating compositional models requires the characterization of minimal assumptions for the robustness of the compositional feature. We develop a framework for a *compositional theory* of RL using a categorical point of view. Given the categorical representation of compositionality, we investigate sufficient conditions under which learning-by-parts results in the same optimal policy as learning on the whole. In particular, our approach introduces a category MDP, whose objects are Markov decision processes (MDPs) acting as models of tasks. We show that MDP admits natural compositional operations, such as certain fiber products and pushouts. These operations make explicit compositional phenomena in RL and unify existing constructions, such as puncturing hazardous states in composite MDPs and incorporating state-action symmetry. We also model sequential task completion by introducing the language of zig-zag diagrams that is an immediate application of the pushout operation in MDP.