Stochastic Differential Equations and Applications

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**Timetable:** 24 hrs. First lecture on May 5, 2020, 11:00 (dates already fixed, see calendar), Torre Archimede, Room 2BC/30.

**Course requirements:**
Basics of real analysis and measure-theoretic probability. Familiarity with continuous-time stochastic processes is advantageous, but not required.

**Examination and grading:**

**SSD:** MAT/06

**Aim:**
Introduce fundamental results and techniques in the theory of stochastic differential equations (SDEs) and illustrate their connections with ordinary and certain classes of partial differential equations. Some applications to optimal control, many-particle systems, and their mutual interplay will be treated.

**Scope:** Focus on SDEs driven by finite-dimensional Wiener processes.

**Course contents:**

1. Itô calculus and variants of Itô’s formula. SDEs driven by Brownian motion (Wiener processes). Questions of existence and uniqueness in weak and strong solutions, results by Yamada-Watanabe. Strong solutions for non-globally Lipschitz coefficients, weak solutions through the Girsanov transformation.


3. Kolmogorov backward and Kolmogorov (Fokker-Planck) forward equation. Differentiation of SDEs with respect to initial conditions and probabilistic solution of linear parabolic PDEs. Feynman-Kac and Bismut-Elworthy-Li formulae. Regularization by noise for ODEs. 1 / 2

4. Stochastic optimal control, dynamic programming and Hamilton-Jacobi- Bellman equation. Control through change-of-measure and backward SDEs. Variational representation of relative entropy and large deviations from the small noise limit.

5. McKean-Vlasov SDEs, nonlinear Kolmogorov equation, and propagation of chaos for mean field systems.

6. If time permits and depending on participants’ interests, introduction to optimal control of McKean-Vlasov SDEs or to mean field games.

DP-5
References:

