Numerical valuation of financial options in the Heston and Heston–Hull–White PDE models

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This talk concerns the numerical solution of multi-dimensional partial differential equations (PDEs) arising in financial option pricing theory. We consider the well-known method-of-lines approach, whereby the PDE is first discretized in the spatial variables, yielding a system of ordinary differential equations (ODEs), which is subsequently solved by a suitable time-discretization method. In general, the obtained systems of ODEs are very large and stiff, and standard time-discretization methods are not effective. For the efficient numerical solution, we study in this talk splitting schemes of the Alternating Direction Implicit (ADI) type. A distinguishing feature of PDEs from finance is the presence of mixed spatial derivative terms, due to correlations between the underlying Brownian motions, and we shall pay particular attention to the numerical treatment of these terms with ADI schemes.

As a first financial application we consider the pricing of European options in the popular Heston stochastic volatility model, which is a time-dependent two-dimensional convection-diffusion equation containing a mixed derivative term. Subsequently, we discuss the pricing of American options in the Heston model, leading to linear complementarity problems. Finally, we deal with the Heston–Hull–White model, which extends the Heston model and forms a time-dependent three-dimensional convection-diffusion equation with mixed derivative terms. Both theoretical stability results and practical numerical experiments will be presented.