

1146-60-128

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We define two new classes of stochastic processes, called tempered fractional Lévy process of the first and second kinds (TFLP and TFLP *II*, respectively). TFLP and TFLP *II* make up very broad finite-variance, generally non-Gaussian families that are constructed by exponentially tempering the power law kernel in the moving average representation of a fractional Lévy process. TFLP and TFLP *II* are transient anomalous diffusion models and, accordingly, their increment processes display semi-long range dependence. We establish the sample path properties of TFLP and TFLP *II*. We further use a flexible framework of tempered fractional derivatives and integrals to develop the theory of stochastic integration with respect to TFLP and TFLP *II*, which may not be semimartingales depending on the value of the memory parameter and choice of marginal distribution. (Received January 14, 2019)