Preface to the special issue on Extreme Events and its Applications

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In popular imagery, extreme events mostly relate to natural disasters such as the earthquakes, floods and cyclones. However, such extreme phenomena occur in other domains as well and indeed lead to major societal and economic impacts. The financial down-turns, power black-outs, internet outages, traffic grid-locks in highways, congestion in communication networks are all now a part of the lore of extreme events. Record breaking events, such as the sport records and other unusual records glorified by the Guiness Book of World Records, also fall in this broad genre of extreme events. As a scientific and mathematical discipline, Extreme Value Theory (EVT) and the theory of records have been much studied in the past half-century both by theory and phenomenology starting with the seminal work of Gumbel (1958). Since then, extreme value theory has relevance for physical process as well, especially in the context of non-equilibrium statisitcal physics. Needless to say that current debates on the climate change effects and the recent financial disasters have led to a resurgence in both the theoretical study of extreme events as well as its contemporary applications. This special issue is an attempt to bring together a collection of articles by experts covering various aspects of current research in the broad area of extreme events and its applications.

In its standard form, the question of extremes is about the distribution of block maxima (or minima) in a sequence of independent and identically distributed (iid) random variables over the real line or a Markov sequence. Under reasonable assumptions, this distribution of block maxima (or minima) tends to one of either Gumbel, Frechet or Weibull distributions depending on how the probability distribution of the original sequence decays in its tail region. Analysing block extrema of sequences is the standard approach though in many practical applications this requires long sequence of data to make robust conclusions. Peaks-Over-Threshold (POT) approach overcomes this drawback to some extent by considering the exceedences of a sequence above a particular threshold. In most cases of practical interest, this approach uses more information available in a given sequence of data in comparison with the block extrema approach. These ideas, in a nutshell, represent the basic framework in a field that is replete with many possibilities and extensions to correlated sequences with application to real-life data. The articles appearing in this special issue represent a cross section of current research done in this field and encompass mathematical theory of extremes, classical and quantum physics to climate and financial applications. The problems addressed in this issue do certainly carry the biases of the authors and their research focus. Yet, all the articles, taken together, present current trends in the study of extreme events. An interested student might find sufficient pointers to pursue research in this area.

We briefly discuss the contributions of the papers in this issue. The contribution of Eliazar Cohen present a simple `pentatonic' classication of the extreme events- ranging from very small to very large outcomes - of positive-valued random variables. Using a formalism designed for statistical mechanics, the classication is based on the analysis of the inherent Gibbsian forces and temperatures existing at the logarithmic scale of the random variables; it allows for the construction of a variety of processes ranging from ones divergent on both sides to processes convergent at both. The paper of Pisarenko Rodkin makes use of EVT in order to fit catastrophic events (earthquakes) based on the classical Kolmogorov-Smirnoff test. In the seismic risk assessment aspect, they develop the idea that the combined use of historical earthquake catalogs with instrumental ones can improve seismic statistics in the higher magnitude domain considerably, since historical catalogs cover very long time periods.

Little attention has been paid when randomness was of deterministic origin. An attempt to fill this gap is discussed in the papers by Profs Nicolis and Nicolis and in the one by Arul Lakshminarayan. The first paper gives an account of EVT in the context of 1D chaotic and quasiperiodic maps, together with a 2D example and the 1D projection of it; results are compared to the iid case, mostly numerically and major differences are found, raising a number of challenges for EVT in the context of chaotic time series. The second paper deals with the record statistics of momentum transport and then the eigenvectors intensities in the classical and quantum standard map; Comparison with the records of Markov sequences or with ones of iid sequences are shown to lead to some informations on the correlations of the system. The paper by Fyodorov and Giraud first develops rigourous results exhibiting a log-correlated structure of the discrete field arising from the eigenvectors of an ensemble of matrices pertaining to the Ruijsenaars-Sheider model describing the motion of a population of relativistic particles. Numerics also provide some evidence of the multifractality of these eigenvectors entries.

The work of Corral revisits the question of scaling of the waiting times between successive occurrences of extreme events with respect to the threshold. For high values of threshold, the moments of inter-event time distribution display power-law in the scale parameter. The paper by Faranda et. al. applies extreme value theory to dissipative and chaotic dynamical systems. The results of this work are relevant for the calculating the parameters of asymptotic distribution of maxima in terms of properties of attractors. In addition, this also discusses how noise effects can be taken care while estimating the parameters of extreme value distributions. The paper by Ramola discusses one of the important models in statistical physics, namely, the branching Brownian motion and some extreme value questions in this correlated system. The analytical results for order and gap statistics of this branching process are supplemented by detailed simulations. It must be pointed out that extreme value statistics for correlated processes is beginning to receive research attention. One of the important applications of extreme value theory is in the area of finance. The paper by Filiminov and Sornette discusses drawdowns as an alternative to the traditional log-returns as a proxy for market risk. Drawdowns (or drawups) measures the combined loss when a stock value crashes from a maxima to a minima. This paper points out that the extreme values in drawdowns lead to strong violations of power law decay of the stock returns. These extreme events have major significance for market dynamics and are referred to as 'dragon-kings' to indicate their importance.

The variety of extremes related problems treated in this special issue not only indicates the state of the art in this area of research but also points to emerging trends. We hope that this special issue will stimulate further research in the area extreme events and its applications.