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Dedicated to the memory of B. A. Sevastyanov

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Contents

On the Time of Attaining a High Level by a Transient Random Walk in Random Environment

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Let (p_i, q_i), $i \in \mathbb{Z}$, be a sequence of independent and identically distributed random vectors such that $p_i + q_i = 1$, $p_i > 0$, $q_i > 0$ for $i \in \mathbb{Z}$. Consider a *random walk in the random environment* $(p_i, q)i)$, $i \in \mathbb{Z}$. It means that if the random environment is fixed then a moving particle fulfils a transition from the state i to the state $(i+1)$ with probability p_i or in the state $(i-1)$ with probability q_i. Let X_n be a position of the moving particle at time n and $X_0 = 0$.

Set $\varkappa = \ln q_0/p_0$. Suppose that $\mathbf{E} \ln \varkappa > 0$. If this condition holds then $\lim_{n\to\infty} X_n = -\infty$. It means that the random walk is *negatively transient*.

Suppose also that $\mathbf{E} \exp(-\varkappa) < +\infty$, therefore the moment generating function $\Theta(t) = \mathbf{E} \exp(t\varkappa)$ exists for $t \in [-1, 0]$. This function is continuous on $[0, 1]$, has the first and second derivatives on $(0, 1)$ and $\lim_{t\to-1} \Theta'(t) = \mathbf{E}(\varkappa \exp(-\varkappa))$, $\lim_{t\to 0} \Theta'(t) = \mathbf{E}\varkappa > 0$. As $\Theta''(t) > 0$ for $t \in (-1, 0)$, the function $\Theta'(t)$ increases on $[-1, 0]$ from the value $\mathbf{E}\varkappa \exp(-\varkappa)$ till the value $\mathbf{E}\varkappa$.

There are the three types of a negatively transient random walk:

1) *strongly transient* when $\mathbf{E}(\varkappa \exp(-\varkappa)) > 0$;

2) *intermediately transient* when $\mathbf{E}(\varkappa \exp(-\varkappa)) = 0$;

3) *weakly transient* when $\mathbf{E}(\varkappa \exp(-\varkappa)) < 0$.

Set $T_n = \min\{k : X_k = n\}$. The asymptotic formula, as $n \to \infty$, for the probability that $T_n < +\infty$ is known in each from the three cases:

$$1) \qquad \mathbf{P}(T_n < +\infty) \sim c_1 \gamma^n,$$

$$2) \qquad \mathbf{P}(T_n < +\infty) \sim c_2 \frac{\gamma^n}{\sqrt{n}},$$

$$3) \qquad \mathbf{P}(T_n < +\infty) \sim c_3 \frac{\gamma^n}{n^{3/2}},$$

where c_1, c_2, c_3 are positive constants, $\gamma = \inf_{t\in[-1,0]} \Theta(t)$.

Theorem. *In the intermediately transient case for* $x > 0$

$$\lim_{n\to\infty} \mathbf{P}\left(\frac{\ln T_n}{\sigma\sqrt{n}} \le x \;\middle|\; T_n < +\infty\right) = K(x),$$

where σ *is a positive constant,* $K(x)$ *is the Kolmogorov distribution function.*

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Equating of Test Scores, Based on Their IRT Calibratiuon

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Common problem, arising in the everyday practice of ability evaluation using tests is how one can compare or equate the scores obtained on different tests or different forms of a same test. Under the main assumption, that these tests are based on the same unidimensional latent trait, their score can be compared using the IRT calibration of the items in both tests. In this paper a procedure for test score equating, based on the sequence of tests with some common items in each test is considered.

Empirical Likelihood Inference with Ranked Set Samples

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We consider nonparametric interval estimation for the population quantiles based on ranked set samples. We derived the large sample distribution of the empirical log likelihood ratio statistic for the quantiles. Approximate intervals for quantiles are obtained by inverting the likelihood ratio statistic. The performance of the empirical likelihood interval is investigated and

compared with the performance of the intervals based on the ranked set sample order statistics.

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Multitype branching processes as models for phytoplankton population

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We propose a general (i.e. Crump–Mode–Jagers) branching process for describing outbreaks of infectious diseases depending on the vaccination coverage of the population. We extend the previous results of Gonz alez et al. ([1], [2]) in several directions that are both practically and theoretically important. Stochastic monotonicity and continuity results for a wide class of functions (e.g. extinction time and total number of births over all time) defined on such a branching process are proved (see [3]) using coupling arguments. These results lead us to obtain optimal vaccination schemes to control corresponding functions (e.g. duration and final size) of epidemic outbreaks. The theory is illustrated by applications to the control of the duration of mumps outbreaks in Bulgaria. Keywords: General branching process, coupling, SIR epidemic model, time to extinction, vaccination policies, Monte-Carlo method, mumps in Bulgaria.

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Invariant Measure for the Stochastic Equation of a Viscous Gas

Azzedine Benchettah

Rym Benseghir, Badji Mokhtar University

We consider a stochastic equation system corresponding to the description of the motion of a barotropic viscous gas in a discretized one-dimensional domain with a weight regularizing the density and prove the existence of an invariant measure for this equation system. The proof is based on the application of Has'minskii's theorem as well as the construction of the solution of the equations with the initial condition.

Keywords: Stochastic equation, viscous gas, invariant measure

Periodic Measure of a Barotropic Viscous Gas in a Discretized One-Dimensional Domain

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A stochastic equation system corresponding to the description of the motion of a barotropic viscous gas in a discretized one-dimensional domain with a weight regularizing the density is considered. In this paper, we study the periodic case, proving the existence of a periodic measure for this problem. The proof is based on the application of the Khasminskii's theorem.

Keywords: Viscous barotropic gas, periodic measure, discretized domain

Estimation of the Solution to Smoluchowski Equation by Weight Statistical Modeling

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We consider the Smoluchowski equation with linear coagulation coefficients depending on two parameters. We construct weight algorithms for estimating various linear functionals in ensemble, which is governed by the equation under study. Constructed algorithms allow us to estimate the functionals for various parameters as well as parametric derivatives using the same set of trajectories.

We discuss some aspects of choosing an auxiliary model for minimizing the parametric maximum of the mean-square error in weighted estimates.

Moreover, we construct value algorithms for two consecutive elementary transitions in Markov chain: the first is simulation of the time between interactions, and the second is sampling of the interacting pair number. Efficiency of the constructed algorithms is supported by numerical estimates for the monomer and dimer concentrations in ensemble.

Keywords: Markov Chain, Integral Equation of the Second Kind, N-Particle System.

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Probability of Undetected Error – an Important Measure of the Performance of Error Detecting Codes

R. Dodunekova, E. Nikolova

How does one select the best code for a particular application? This is not easy question to answer in general because many factors need to be considered. In order to choose the most appropriate code for a given application we are interested of its error-control capabilities. Important measures of these capabilities are the minimum distance of the code, which gives the number of detectable and correctable errors, the probability of undetected error and the probability of correct decoding. When we want to find an $[n, k]$ code for error detection or correction in some applications, the best choice is a code with minimum probability of undetected error. To find a code with the smallest undetected error probability for a certain channel, one has to use exhaustive search since presently a general method for finding such are code does not exist. Very often the channel error probability is not a fixed value, i.e. changes during the time of the transmission. A code with the smallest undetected error probability for ε' may not have the smallest undetected error probability for $\varepsilon \neq \varepsilon'$, even when ε and ε' are very close to each other. Therefore, it is useful to have some criteria by which we can judge the usefulness of a given code for error detection. The property of goodness and properness are to be preferred in such cases. In this work, we will focus our attention on known methods and techniques for the study of block codes with respect to this property, together with application to families of block codes.

Exit Levels of Diffusion Processes and Two Classical Problems for a First Hitting Time

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The two problems we discuss here concern the exit probabilities and densities of diffusion processes in case of two-sided boundaries. Introducing the concept of exit levels, we find large families of boundaries for which the exit probabilities admit closed representation. Next, applying the theory of conditional processes, we show that the problem concerning the exit densities can be reduced to two simpler problems- a two-sided exit probability problem for the original process and an one-sided boundary problem for a suitable conditional process.

Surface Waters Analysis of the Bulgarian Danube transborder region

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Based on official data, a comparative analysis of the surface water along the rivers flowing into the Danube river in the transborder area Bulgaria – Romania is presented. The content of dissolved oxygen, nitrate nitrogen, dissolved oxygen and Biological and Chemical Oxygen Demand for a five year period 2009—2013 is analyzed. The aim is the dynamics of these indicators and the reasons for the current exceedances to be traced and analyzed. Measures for improving the condition of the surface runoff are also proposed.

Multivariate Processes with Heavy Tails and Applications in Finance

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Numerical studies have empirically observed that financial asset returns are skewed and fat tailed. More- over, the amplitude of returns varies across time, behavior referred to as volatility clustering. The problem is further complicated by the fact that investors often hold portfolios with multiple and also very complex assets. The behavior of the assets and their underlying risk factors is observed to be asymmetrical especially in crisis periods. Thus modeling the dependence structure of financial time series turns into a critical point.

In this work we focus on the research of the available multivariate models for modeling time series and multivariate GARCH in particular. We utilize non-Gaussian distributions which allows us to capture both fat tails and asymmetrical dependence of the data.

Keywords: Heavy tails, Multivariate distributions, Multivariate GARCH

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Recent Results on Controlled Branching Processes

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A controlled branching processes (CBP) is a stochastic growth population model in which the number of individuals with reproductive capacity in each generation is controlled by a random control function. This model was introduced by Yanev (1976), although its precursor was the model intoduced by Sevastyanov and Zubkov (1974) with deterministic control function. In practice, this branching model could describe reasonably the probabilistic evolution of populations in which, for various reasons of an environmental, social, or other nature, there is a mechanism that establishes the number of progenitors which take part in each generation. For example, in an ecological context, the control of an invasive animal species keeping it between admissible limits can be model by these processes. Another practical situation that can be modeled by this kind of process is the evolution of an animal population that is threatened by the existence of predators. A CBP can be also used to model the evolution of the number of individuals of a population in which the rate of growth not only depends on the current population size but also on the distance between this size and the carrying capacity of the environment, that is the maximum population size that the environment can admit in view of its resources. Also, models with different kinds of migration are particular cases of the CBP. In this work we review some of the main features of these processes (expected values, extinction conditions, long-term behavior, inference) and develop new theory on particular CBPs of special interest. Keywords: controlled process, extinction, asymptotic behavior, inference, carrying capacity

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Correlated Probit Analysis of Repeatedly Measured Continuous and Ordinal Outcomes with Application to the Health And Retirement Study

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The Health and Retirement Study (HRS) was a longitudinal survey conducted among American citizens born between 1931 and 1941 and their spouses. Several waves of data were collected at intervals of two years. At each interview participants provided information about their self-rated health, body mass index, smoking status and many other characteristics. The variable self-rated health is a 5-level ordered categorical variable while BMI can be treated as a continuous measure. We investigate the effect of smoking on self-reported health and body mass index simultaneously across the seven waves of data with the help of a joint correlated probit model with random effects. Similar models have been considered by Catalano (1997) [1], Regan and Catalano (2000) [3] and Gueorguieva and Sanacora (2006) [2], however parameter estimation based on quasi-likelihood approach or numerical approximations may either provide biased results or even fail to provide estimates due to the computational complexity of the problem. We propose a novel EM algorithm for estimation of the unknown parameters in the model and a Monte Carlo approach to the bootstrap method for standard errors approximation. The EM algorithm converges to the maximum likelihood estimates and thus provides unbiased results in large samples and its computational complexity does not increase exponentially with the increase of the dimensionality of the random effects. Joint analysis of the outcomes has several advantages over separate analyses: we can test the effects of several predictors in the different sub-models while controlling type I error, we can improve efficiency of the estimates and we can assess the correlation between mod- eled variables. To implement the algorithm, we created R functions and to assess the performance of the method, we conducted a limited simulation study. Results from the simulation study and from the analysis of the first seven waves of HRS data will be presented.

Keywords: correlated probit model, EM algorithm, longitudinal data, random effects

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Classes of Equivalence and Identifiability of Age Dependent Branching Processes

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Age-dependent branching processes are increasely used in analyses of biological data. Despite being central to most statistical procedures, the identiability of these models has not been studied. We partition a family of age-dependent branching processes into equivalence classes over which the distribution of the population size remains identical and apply this result to study identiability of the offspring and lifespan distributions of families of branching processes.

Branching Populations with Mating and Reproduction Influenced by the Number of Females and Males

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We introduce a class of two-sex branching models where, in each generation, mating between females and males is randomly governed by Bernoulli distributions allowing each female to mate with one male at most, and each male to mate with several females. Moreover mating as well as reproduction are influenced by the number of females and males in the population. We study here the extinction versus possible persistence of the process. First we investigate sufficient conditions for the extinction-explosion of the population. Then we study conditions which guarantee the almost sure extinction of the population or its persistence with a positive probability.

Keywords: Branching process, two-sex process, population dependent process, extinction, persistence.

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On the Life of Branching Populations in Habitats with Constant Carrying Capacity

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It is a consequence of general probabilistic results that any proper population which cannot grow beyond all bounds must eventually die out.

We investigate the meaning of this more in detail for populations living in a habitat with a constant carrying capacity, i.e. an environment such that reproduction becomes subcritical when the population size exceeds

the carrying capacity, whereas it is supercritical otherwise (while there is enough space and food). We discuss the life career of such populations, their establishment or not, exponential growth, persistence time while lingering around the carrying capacity, their decay, and ultimate extinction.

A Survey on Mixed Poisson process

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The Negative Binomial distribution arises as a counting distribution of Mixed Poisson process with Gamma mixing variable. We consider Mixed Poisson Process with Pareto mixing variable and call the distribution of the number of events up to time t, Mixed Poisson Pareto distribution. The distribution of the inter-renewal times is a Gamma-Pareto distribution. A survey of the results is made and some new properties are proven. An interpretation of the results in the the terms of risk theory is given. Short empirical investigation illustrate the results and show their application.

The Age Structure of Population-Dependent General Branching Processes in Environments with A High Carrying Capacity

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The age structure of populations supercritical below and subcritical above a carrying capacity is investigated, the result being a law of large numbers for measure-valued population processes, as the capacity increases and time passes, provided the starting population is not little. The limit is identified and shown to satisfy a weak version of the Von Foerster partial differential equation. Joint work with Peter Jagers (Chalmers) and Kais Hamza (Monash)

Finite-Time Blowup of a Semi-Linear SPDE with Fractional Noise

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We consider stochastic equations of the prototype

$$du(t,x) = \left(\Delta u(t,x) + \gamma u(t,x) + u(t,x)^{1+\beta}\right) dt + \kappa u(t,x) dB_t^H$$

on a smooth domain $D \subset \mathbb{R}^d$, with Dirichlet boundary condition, where $\beta > 0$, γ and κ are constants and $\{B_t^H,\ t \geq 0\}$ is a real-valued fractional Brownian motion with Hurst index $H > 1/2$. By means of the associated random partial differential equation, obtained by the transformation $v(t,x) = u(t,x)\exp\{\kappa B_t^H\}$, lower and upper bounds for the blowup time of u are given. Sufficient conditions for blowup in finite time and for the existence of a global solution are deduced in terms of the parameters of the equation.

Statistical Simulation of the Vehicular Traffic Flow within the Kinetic Model

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We consider an acceleration oriented vehicular traffic flow (VTF) model. A special feature of this model is introduction of the acceleration variable into the set of phase coordinates, which describe the state of a vehicle. In contrast to the gas dynamics, the interaction in the system results not in a velocity jump, but in an acceleration one. For the original probabilistic VTF model we construct an integral equation of the second kind, which is related to a linear many-particle model describing the vehicle system evolution. We also propose Monte Carlo algorithms for estimating the functionals of the solution to the obtained equation. The practical suitability of this

approach to the solution of the traffic problems is demonstrated by numerical experiments in which we estimate functionals for various car densities and interaction profiles.

Keywords: Evolution of Many-Particle System, Acceleration Jump Process, Interaction Profile.

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Type II family of Bivariate Inflated-parameter Generalized Power Series Distributions

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The family of Inflated–parameter Generalized Power Series distributions (IGPSD) was introduced by Minkova in 2002 as a compound Generalized Power Series distributions (GPSD) with geometric compounding distribution. In these notes we introduce a family of compound GPSDs with bivariate geometric compounding distribution. The probability mass function, recursion formulas, conditional distributions and some properties are given. A member of this family is a Type II bivariate Pólya-Aeppli distribution, introduced by Minkova and Balakrishanan (2014). In this notes the particular cases of bivariate compound binomial, negative binomial and logarithmic series distributions are analyzed in detail.

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I-Delaporte process and Applications

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In this paper we introduce a mixed Pólya-Aeppli process with shifted gamma mixing distribution and call it an Inflated-parameter Delaporte process (I-Delaporte). We derive the probability mass function, recursion formulas and some basic properties. Then we define the process as a pure birth process and derive differential equations for the probabilities. As application, we consider a risk model in which the claim counting process is the defined I-Delaporte process. For the defined risk model we derive the joint distribution of the time to ruin and the deficit at ruin as well as the ruin probability. We discuss in detail the particular case of exponentially distributed claims.

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Stability and Finite-time Blowup of a Family of Semilinear SPDEs with Time-dependent Coefficients

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We investigate the blowup and stability of semilinear stochastic partial differential equations with time-dependent coefficients using stopping times and a non-homogeneous heat semigroup. In particular we derive lower bounds for the probability of blowup in finite times and give existence conditions for global positive solutions.

Keywords: stochastic partial differential equations, blowup of semilinear equations, weak and mild solutions

On the Sojourn Time of a Random Walk on a Half-Axis

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Let $\{X_n, n \geq 1\}$ be a sequence of i.i.d. random variables, $S_n = X_1 + \cdots + X_n$. For $b \geq 0$ we consider the sojourn time

$$T_n = T_n(b) = \sum_{k=1}^{n} I_{\{Sk>b\}},$$

where $I_A(\omega) = 1$ if $\omega \in A$ and $I_A(\omega) = 0$ otherwise.

We present the following results:

1. Explicit expressions for $f(z, u, \lambda) := \sum_{n=1}^{\infty} z^n \mathbf{E}(u^{T_n} \exp\{\lambda S_n\})$.

2. Asymptotic representation for $f(z, u, \lambda)$ as $b \to \infty$ under Cramér condition on the distribution of X_1.

3. Complete asymptotic expansions for $\mathbf{P}(T_n = k)$ as $n \to \infty$, $b = b(n) \to \infty$, $b = o(n)$ under Cramér condition.

4. Asymptotic representations for $\mathbf{E}T_n$ as $n \to \infty$, $b = b(n) \to \infty$, under a) Cramér condition on the distribution of X_1; b) regular variation of the tail distribution of X_1.

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Monte Carlo Method for Estimating Eigenvalues and Eigenfunctions of the Laplace Operator

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This talk present new Monte Carlo estimates for eigenvalues and eigenfunctions of Laplace operator. A triangle domain with mixed boundary conditions is considered. To construct the required estimates, the initial differential problem is reduced to corresponding system of linear equations by replacing differential operators to finite-difference one. We solve the system of linear equations with an ad-joint algorithm "walk on a lattice", whose trajectories are realizations of the certain Markov chain. To construct implemented algorithm, randomization of obtained equations is used and is taken into account in the auxiliary multiplicative weights. In the constructed parallel algorithms, a choice between breakage of trajectories and theirs rebound into the domain is implemented.

Keywords: Monte Carlo methods; eigenvalues; BVP; "random walks" algorithms

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On the Introducing of Notions Probability and Random variable

Plamen Mateev

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An approach introducing probabilistic knowledge based on the "random variable" as the central concept is discussed. A simple scheme of the relationships of random variable with some basic notions as risk, task, problem, science, knowledge, data, information make easier to avoid ambiguity.

Keywords: random variable, statistical education, information technologies, DIKW

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Approaches to modeling of biological data with GraphPad Prism

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The aim of the presented work is to show possibilities of GraphPad Prism 6 Software for biological data modeling. GraphPad Prism 6 combines nonlinear regression (curve fitting), basic biostatistics, and scientific graphing. We present how to pick a model that corresponds to the experimental design from Prism's a menu of the equations biologists use most and also how to enter your own equation. When fitting biological data with regression, main objective is often to discriminate between different models. We discuss two distinct approaches to comparing models. The first method is based on statistical hypothesis testing and ANOVA (analysis of variance). It is based on analyzing the difference between the sum-of-squares of the two models. These ANOVA calculations compute an F ratio and a P value. The second method for comparing models is based on information theory. This method calculates Akaike's Information Criterion (AIC) which answers the questions: "Which model is more likely to have generated the data?", and "How much more likely?".

Keywords: Biological data modeling, Regression, Model selection, Akaike's information criteria (AIC), F test.

Sevastyanov Branching Processes with Non-homogeneous Poisson Immigration

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Sevastyanov age-dependent branching processes allowing an immigration component are considered in the case when the moments of immigration form a non-homogeneous Poisson process with intensity $r(t)$. The asymptotic behavior of the expectation and of the probability for non-extinction is investigated in the critical case depending from the asymptotic rate of $r(t)$. Corresponding limit theorems are also proved using different types of normalization. Among them we obtained limiting distributions similar to the classical ones of Yaglom (1947) and Sevastyanov (1957) and discovered also new phenomena due to the non-homogeneity.

Large and Moderate Large Deviations for General Renewal Processes

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Let $\{(\tau_i, \xi_i); i = 1, 2, \dots\}$ be a sequence of i.i.d. random vectors, $\mathbf{P}(\tau_1 > 0) = 1$. Put

$$T_n := \tau_1 + \cdots + \tau_? n, \quad S_n := \xi_1 + \cdots + \xi_n \text{ for } n \geq 1.$$

We study large deviations and moderate large deviations for the general renewal process

$$Z(t) := S_{\eta(t)}, \quad t \geq 0,$$

where $\eta(t) := \min\{m \geq 0 : T_{m+1} \geq t\}$. The formula

$$\lim_{\varepsilon \to 0} \lim_{T \to \infty} \frac{1}{T} \ln \mathbf{P}\left(\frac{1}{T} Z(T) \in (\alpha - \varepsilon, \alpha + \varepsilon)\right) = -G(\alpha),$$

where the function $G(\alpha)$ is known in an explicit form, is proposed. Put

$$z_T(t) := \frac{1}{x} Z(tT), \quad 0 \le t \le 1,$$

where a function $x = x(T) > 0$is such that $x \sim T$ as $T \to \infty$. Large deviation principle for $\{z_T(\cdot); T > 0\}$ was obtained:

$$\ln \mathbf{P}(z_T(\cdot) \in B) \sim -T \inf_{f \in B} I(f),$$

where $I(f) := \int_0^1 G(f'(t))dt$ for absolutely continuous functions, $f(0) = 0$, and B is a sufficiently wide class of functions $f = f(t)$; $0 \le t \le 1$.

In the lattice case $\mathbf{P}((\tau_1, \xi_1) \in \mathbb{Z}^2) = 1$, the sharp asymptotics of large deviation probabilities for $Z(n)$ is proposed:

$$\mathbf{P}(Z(n) = k) \sim \frac{C(\alpha)}{\sqrt{n}} e^{-nG(\frac{k}{n})}$$

for $k = k_n \in \mathbb{Z}$, $k \sim n\alpha$ as $n \to \infty$,where the function $C(\alpha)$ is known in an explicit form.

Similar results in the domain of moderate large deviations for $Z(t)$ are obtained.

Sampling Parts of Random Integer Partitions: A Probabilistic and Asymptotic Analysis

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Let λ be a partition of the positive integer n, selected uniformly at random among all such partitions. Corteel et al. (1999) proposed three different procedures of sampling parts of λ at random. They obtained limiting distributions of the multiplicity $\mu_n = \mu_n(\lambda)$ of the randomly-chosen part as $n \to \infty$. The asymptotic behavior of the part size $\sigma_n = \sigma_n(\lambda)$, under these sampling conditions was found by Fristedt (1993) and Mutafchiev (2013).

All these results motivated us to study the relationship between the size and the multiplicity of a randomly-selected part of a random partition. We describe it obtaining the joint limiting distributions of (μ_n, σ_n), as $n \to \infty$, for all these three sampling procedures. It turns out that different sampling plans lead to different limiting distributions for (μ_n, σ_n). Our results generalize those obtained earlier and confirm the known expressions for the marginal limiting distributions of μ_n and σ_n.

The Normal Tempered Stable and The Normal Inverse Gaussian Distributions

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The Normal Tempered Stable distribution is a Normal variance-mean mixture with a Tempered Stable mixing distribution. In this note, we will define the class of NTS distributions, in particular, we will be interested in particular in one of the members of the class – the Normal Inverse Gaussian distribution, where the mixing distribution is an Inverse-Gaussian and closed-form expressions exist for both the mixing and the mixture probability density functions. We will explore different derivations of the class and its members, their parametrizations as well as present some results concerning the parameter estimation of the distributions.

Keywords: Scale normal mixtures, Heavy tailed distributions, Parameter Estimation, Financial Data

MDL Principle for Distributions with Shape Parameters

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While in theory many processes should have normal distribution or at least show asymptotic normality, in practice they often exhibit fat-tail distributions. Non-normality is hard to model, but also hard to detect (model selection). The Minimum Description Length principle applies Shannon's information theory in statistical enquiry to balance between goodness of fit and model complexity. More specifically, the Normalized Maximum Likelihood (NML) model, stochastic distribution complexity are discussed. This paper presents the calculation of the model complexity for distributions that combine scale-location parameters with other parameters (shape parameters). The working example is Student-T with free degrees of freedom.

Calibration of p-values for Multiple Testing Problems in Genomics

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Conservative statistical tests are often used in complex multiple testing settings in which computing the type I error maybe difficult. In such tests, the reported p-value for a hypothesis can understate the evidence against the null hypothesis and consequently statistical power may be lost. False Discovery Rate adjustments, used in multiple comparison settings, can worsen the unfavorable effect. Despite these effects, the problem seems to be somewhat overlooked within the biostatistics and bioinformatics communities, with many practitioners not even aware of the issue. We present a computationally efficient and test-agnostic calibration technique that can

substantially reduce the conservativeness of such tests. As a consequence, a lower sample size might be sufficient to reject the null hypothesis for true alternatives, and experimental costs can be lowered. As an example, we apply the calibration technique to the results of DESeq, a popular method for detecting differentially expressed genes from high-throughput RNA sequencing data. The increase in power maybe particularly high in small sample size experiments, often used in preliminary experiments and funding applications. In some situations, after correction, statistical power can increase 3 fold without the need of additional experimental costs.

On Limit Laws for Central Order Statistics Under Power Normalization

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Barakat and Omar (2011) wrote: power normalization and linear normalization of central order statistics are leading to the same families of limit distributions. Hereby we check their statement.

Let k_n be a sequence of integers such that $k_n/n \to \theta \in (0,1)$ and $X_{k_n,n}$ be the k_n-th upper order statistic from a sample of iid rvs $X_1, \ldots, X_n$ with continuous df F, i.e. $X_{n,n} < \cdots < X_{k_n,n} < \cdots < X_{1,n}$. We denote by GMA the group of all max-automorphisms of $\mathbb{R}$ w.r.t. the composition, which are continuous and strictly increasing mappings $G : \mathbb{R} \to \mathbb{R}$.

In Pancheva and Gacovska (2013) the authors have proved that for a sequence $G_n \subset GMA$

(1) $P(G_n^{-1}(X_{k_n,n}) < x) \xrightarrow{w} H(x)$ iff

(2) $\sqrt{n}\frac{\theta - \overline{F}(G_n(x))}{\sqrt{\theta(1-\theta)}} \xrightarrow{w} \tau(x)$,

where $\tau(x)$ is a non-decreasing function uniquely determined by the equation $H(x) = \Phi(\tau(x))$ with Φ – the standard normal df. Moreover, if G_n is regular, i.e. there exists $\lim_{n\to\infty} G_{[nt]}^{-1} \circ G_n(x) = g_t(x) \in GMA$ for all $t > 0$, then τ satisfies the following functional equation:

(3) $\sqrt{t} \cdot \tau(x) = \tau(g_t(x))$, for all $t > 0$.

Solving (3), if given that $g_t(x) = a_t x + b_t$, $a_t > 0$, $b_t \in \mathbb{R}$, Smirnov (1949) derived four different types of limit laws, e.g. $H_1(x) = \Phi(cx^\alpha)$, $\alpha > 0$, $c > 0$, $x \geq 0$ and $H_4(x)$ is the two jumps distribution with jump high $1/2$.

Here we solve (3), given that $g_t(x) = b_t|x|^{a_t} \cdot sign(x)$, $b_t > 0$, $a_t > 0$, $a_t \neq 1$ and obtain 12 different types of limit laws, under which $H_5(x) = \Phi(c|\log|x||^\alpha)$, $c > 0$, $\alpha > 0$, $x \in (-1, 0)$. The two jumps distribution does not appear as limit under power normalization.

Keywords: k-th upper order statistic, Central rank, Monotone normalization,Power normalization, Regular norming sequence

2000 Mathematics Subject Classification. 62G20, 62G30, 62E20.

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Modeling Survival in Childhood Acute Lymphoblast Leukaemia

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Acute lymphoblastic leukemia (ALL) is the most common malignancy diagnosed in children, representing nearly one third of all pediatric cancers. About 30% of the children with ALL have a gene marker. The most frequent abnormality is in TEL-AML1 gene rearrangement and this marker can be detected in 25% of the cases with ALL. In this paper the survival analysis is used to determine the prognostic significance of TEL-AML1 and to models the time it takes for relapse or death. The data are from 160 patients, observed in Specialized Children's Oncohematology Hospital – Sofia,

Bulgaria, for a time of 8 years. The gene marker TEL-AML1 is detected in 33 of the patients. For estimating event (relapse or death) free survival rate the Kaplan–Meier method is used. Time to event (in months) is calculated as the time from study entry to first event or data of last contact. The log-rank test is used for comparison of survival curves between two groups (with and without TEL–AML1). Multivariate analysis is conducted by using Cox proportional hazards regression.

Keywords: survival analysis, Kaplan–Meier estimator, Cox Proportional Hazards Regression

2000 Mathematics Subject Classification: 92B15, 62P10

Parameter Estimation for a Branching Ornstein-Uhlenbeck Process

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We use Yule's pure birth process tree conditioned on having N tips for modeling the unknown phylogenetic tree for N related species. The current trait values $(X_1, \ldots, X_N)$ for this group of species are assumed to evolve from a common ancestral state X_0 according to the Ornstein-Uhlenbeck process. We study the properties of the sample mean and sample variance for the sample $(X_1, \ldots, X_N)$ consisting of dependent observations. As a result we are able to produce point and interval estimates for the key parameters of the evolutionary model in question.

Keywords: Conditioned Yule process, Ornstein-Uhlenbeck process, comparative phylogenetics

Inverse Adaptive Cluster Sampling with Unequal Selection Probabilities: Case Studies on Crab Holes and Arsenic Pollution

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Adaptive cluster sampling was developed as an efficient method for estimating rare and clustered populations. The method mimics how biologists would like to collect data in the field by targeting survey effort to localized areas where the rare population occurs. Another popular sampling design is inverse sampling. It was developed to achieve a predetermined sized sample of rare events. Ideally the resultant sample will be sufficiently large to ensure reliable estimates of population parameters.These two designs motivated us to introduce inverse adaptive cluster sampling with unequal selection probabilities.We develop an unbiased estimator of the population total, and numerical approximations for it. The efficiency of the introduced estimators are illustrated by simulation studies of two real populations: crabs in Al Khor-Qatar and arsenic pollution in Kurdistan-Iran. Simulation results show that our introduced estimators are efficient.

Keywords: Adaptive cluster sampling, Murthy's estimator, Raj's estimator, Rare and clustered population, Sampling without replacement.

Minimum Cross-Entropy Based Weights in Dynamic Diffusion Estimation in Exponential Family

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In this contribution we focus on recently introduced dynamic distributed estimation in exponential family of distributions [1]. We consider a set of cooperative nodes, modelling a random variable with a probability density function (pdf), depending on an unknown parameter θ. In order to improve their estimates of this parameter, nodes share the observations and/or the estimates of parameter θ. Since the method exploits the Bayes rule, nodes are also allowed to share the hyperparameters.

Based on data provided we distinguish between two phases: the adaptation phase and the combination phase. In the adaptive phase we first consider minimization of a cost function based on the Kullback- leibler (KL) divergence resulting in the weighted geometric mean of pdfs of observations. It then enters the Bayes rule and leads to up- date of the hyperparameters. In the combination phase nodes share their hyperparamters and/or the estimates of parameter θ. We then again exploit the KL divergence and obtain either weighted linear combination of provided hyperparameters or estimates of parame- ter. By repeating the diffusion part whenever new observations and estimates are available we obtain a dynamic version.

The inseparable part of the procedure is the assignment of weights. Static weights, which do not change with new set of data, lead to estimates with reasonable properties but do not reflect nodes' relia- bility. Thus we suggest to model also the weights in order to reflect the reliability and to improve the resulting estimates of parameter θ. The minimum cross-entropy principle allows us to obtain a new probability distribution function over the weights with every new set of data. The additional constraints on expected values of the KL divergences help us distinguish changes in the nodes estimates and capture probable failures of nodes.

Keywords: Bayes rule, Kullback-Leibler divergence, minimum cross-entropy principle.

Acknowledgements: The work was supported by the grants GACR 13-13502S and SVV-2014-260105.

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Stochastic Stability of Predator-prey Model of Holling Type II and Leslie-Gower with Refuge Term

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In this paper we consider a prey-predator system where the prey population is infected by a microparasite. Local as well as global stability properties of the interior equilibrium point are discussed. The stochastic stability properties of the model are investigated, suggesting that the deterministic model is robust with respect to stochastic perturbations.

Keywords: Stochastic stability, Predator-prey, Holling Type II, Leslie-Gower

Asymptotic Expansions for Stochastic Differential Equations with Small Multiplicative Noise

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Asymptotic expansions are derived as power series in a small coefficients in front of a multiplicative noise or deterministic driving term in a nonlinear evolution equation, the noise is of Lèvy type. Estimates on remainders will be provided in this talk.

Keywords: SDEs, asymptotic expansions, processes driven by multiplicative Lévy noise

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Inverse Adaptive Cluster Sampling with Unequal Selection Probabilities: Case Studies on Crab Holes and Arsenic Pollution

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In the present work we consider a multitype discrete time branching process with multivariate power series offspring distributions. We construct the maximum likelihood estimators of its parameters, which coincide with the Harris type estimator of the mean vector, and study their behaviour in the presence of outliers. On the basis of samples from the entire family tree we construct the trimmed likelihood estimators and find a lower of bound of their breakdown point. We propose an iterative method for robust estimation on the basis of the generation sizes of the process, combining the trimmed likelihood estimation and random generation methodology.

Keywords: Multitype branching processes, power series distributions, trimmed likelihood

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One Parametrisation and Some Special Cases of Additive Processes

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A parameterization of additive processes is presented. A family of probability distributions called switch time family is introduced – $STF(n, \beta,)$ – with two representatives $ST1(n, \beta,)$ distribution and $ST2(n, \beta,)$ distribution. Corresponding stochastic processes are defined and studied. Simulation and graphics of the distributions and the processes in R languages are done as well as some applications.

Keywords: additive processes, parameterization, switch time family distributions and processes, simulation

Multitype Branching Processes as Models for Phytoplankton Population

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The purpose of this research is to model a phytoplankton population localized to a particular geographical longitude, latitude and depth and try to draw conclusions about its evolution. Actually, we consider the concentration of chlorophyll-a, which is contained in the phytoplankton cells.

We propose a multitype branching model describing the dynamics of populations of phyto- plankton cells and of chlorophyll-a content, where the type is the number of cells containing in unit volume. Considering these TpseudoУ P individuals we allow that one of the n cells of an individual of type n can divide or die and one of its bonds splits. The asymptotic behaviour of the mean number of cells of each type is obtained.

Keywords: Multitype age-dependent branching processes, phytoplankton population, Malthusian parameter

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Dynamic of Two-type Bellman–Harris Process Beginning from a Large Number of Particles

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We investigate a two-type critical Bellman–Harris branching process with the following properties: the tail of the life-length distribution of the first type particles is of order $o(t^{-2})$, the tail of the life-length distribution of the second type particles is regularly varying at infinity with index $-\beta$, $\beta \in (0, 1]$, at time $t = 0$ the process starts with a large number N of the second type particles and no particles of the first type. It is shown that the time axis $0 \leq t < \infty$ splits into several regions whose ranges depend on β and the ratio N/t within each of which the process at time t exhibits asymptotics (as $N, t \to \infty$) which is different from those in the other regions.

The preliminary version of publication look in: Vladimir Vatutin, Alexander Iksanov, Valentin Topchii, A two-type Bellman–Harris process initiated by a large number of particles, 2013, 42 pp., arXiv: arxiv.org/abs/1311.1060

Keywords: two-type critical Bellman–Harris branching process

Crump–Mode–Jagers Branching Processes as Demographic Models

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Forecasting the structure of a human population and human resources in particular, is an important problem whose decision has strong impact to all branches of economics and social practices in all societies. Knowing the current demographic conditions and the expected ones in the future, we can adjust certain social policies, so that the population structure and the economy as a whole, could be improved in long term. On the other hand, projecting some properties of the population like the working force of the country, gives us information about how we should change the retirement age for men and women, for example. The governments should be mindful of the processes happening in the population structure, in order to conduct their policy most effectively. First, the general branching processes setting is an appropriate tool for solving this problem (see [1] and [2]). Second, using their generalization, we model a human population that begins with the current population structure, in which every woman could have one or more children in different moments in her life and the life length of women and men are random variables. Finally, we deal with the temporal changes in birth and death processes and forecast the future changes in some key demographic properties.

Keywords: General branching process, demography, Malthusian parameter

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Scientific Results of Sevastyanov

Vladimir A. Vatutin

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In the talk I give a survey of results due to Sevastyanov in branching processes, random allocations and other fields of probability theory. Some photos related to Sevastyanov's life will be shown.

Keywords: branching processes, random allocations

Marginal Densities of the Wishart Distribution Corresponding to Non-Decomposable Graphs

Evelina Veleva

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The aim of the paper is to find the marginal densities of the Wishart distribution, corresponding to non-decomposable graphs. Each non-decomposable graph consists of at least one cycle with 4 or more edges. Using the results for decomposable graphs, it is shown how by Monte Carlo method for numerical integration a marginal density, corresponding to a cyclic graph with n edges, can be computed at any point. Keywords: Wishart distribution, non-decomposable graph, marginal density, covariance matrix, graphical Gaussian models

On a Number of Components in a Random A-Mapping

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Suppose that $\mathfrak{S}_n$ is the semigroup of all mappings of the set of n elements into itself, A is a fixed subset of the set of natural numbers $\mathbb{N}$, and $V_n(A)$ is the set of mappings from $\mathfrak{S}_n$ whose contours are of sizes belonging to A. Mappings from $V_n(A)$ are usually called A-mappings. Consider a random mapping σ_n, uniformly distributed on $V_n(A)$. It is supposed that the set A has an asymptotic density $\varrho > 0$. Let ν_n be a number of connected components of a random mapping σ_n. It is shown by the author that a random variable ν_n is asymptotically normal with mathematical expectation $a(n) = \sum_{k \in A(\sqrt{n})} 1/k$ and variance $\varrho \ln(n)/2$, where $A(t) = \{k\colon k \in A, k \geq t\}$. We use in proof the method based on Tauberian theorems. Such approach firstly in the branching processes was used by B. A. Sevastyanov [1]. The development of such method was realised in the author's book [2].

Keywords: random A-mappings, random A-permutations, cyclic points, contours, trees, components of random mappings, Tauberian lemma. 05 Combinatorics.

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Controlled Branching Processes and their Relatives

George Yanev

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In 1974 Sevastyanov introduced a general class of branching stochastic processes for modeling the evolution of a population. A significant generalization of this class pertaining to random control functions was proposed by Yanev (no relation to the speaker) in 1975. Controlled branching processes include the important sub-classes of processes with different regimes of immigration and emigration and regenerative processes among others. The Bulgarian school of probability and statistics has been actively involved in the study of controlled branching processes since the beginning. Under the visionary leadership and mentorship of Nikolay Yanev (a.k.a. "The Captain"), a dynamic group of Bulgarian mathematicians has made significant contributions to both theory and applications of these stochastic models (see [1]). The aim of this talk is to present a brief overview of some results for controlled branching processes, especially those obtained by Bulgarian mathematicians and their collaborators. We will also discuss connections and applications to other branching models.

Keywords: branching processes, immigration, migration, random control, discrete time

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Neural Network Versus Time Series Methods for Forecasting of PM10 in Doha

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In addition to the sand storms Qatar is witnessing a massive number of construction projects during the last ten years, which resulted in enormous dust emissions. Particulate matter or particle pollution (PM), is a complex mixture of extremely small particles and liquid droplets, and has direct effect on cardiac and respiratory problems.. The data for this study was collected from three different monitoring stations for the period between 2007 – 2011 on a daily and hourly basis. The main objective of this study is to examine the trend of the PM10 in Qatar using Open Air graphing techniques from R, and building forecasting models using neural network and time series. This study showed that the data obtained from air pollutants monitoring stations in Doha city exhibits a significant increasing trend in PM10 concentration since the starting of the monitoring program in 2007. Pearson correlation coefficient between the PM10 concentration and temperature and wind speed was significant. The PM10 Rose indicated high concentration in the location where construction projects are taking place. The neural network forecasting technique outperformed time series one.

Keywords: Doha, PM 10, NNW, ARIMA, Air Quality

Compative Analysis of the Treatment with Laser Therapy

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The aim of our research work is the establishment of the difference before and after laser therapy. For the purposes of our work we did preliminary statistical analysis of the data utilising box plot and QQ plot and after that applying t-test to the data.

Please open the link `http://www.youtube.com/watch?v=prZusXxGBmc` to look at the clip and to hear the song "The Souvenir for Pomorie" (very famous in Bulgaria). Please learn the melody and try to sing the following English version:

Pomórie

Pomórie is close to the sea,
it means the name, as you can now see,
and very close to Burgás –
Pomórie is beautiful for us!

The town soft, discreet and chic,
the crazy moments you can pick,
the dolphins, ships and pubs as pearls,
the streets are full of lovely girls!

Refrain

Pomórie is so charming,
the souvenirs of lovely days,
with the dolphins you are diving
and kissing girls on their face ...

The town ancient and stochastic,
the poet lyric and majestic,
the songs are flying on the night,
the girls are beautiful and right!

The town old is nice attractive
with the spirit old collective,
the stars, the moon, the sun, the shine,
and boats, fishes, old wine!

Refrain

Pomórie is so charming,
the souvenirs of lovely days,
with the dolphins you are diving
and dreaming kisses on the face ...