IOP Complexity and Nonlinear Physics Group Summer Meeting
4th June 2013, St Hilda's College, Oxford

Draft Schedule

Time	Presenter	Title
1.00pm	Robin Ball	Ponytails, Catapults and Chaos: Physics of Hair
2.00pm	Dmitri (Mitya) Pushkin	Stirring by microorganisms
2.20pm	Philip Clemson	Chronotaxic systems: complexity from stability
2.40pm	Fred Farrell	Collective behaviour in bacterial biofilms
3.00pm	Jean Boulton	Applications of Complexity in International Development
Tea Break		
3.40pm	John Fry	Bubbles, antibubbles and elementary technical analysis via econophysics
4.00pm	Simon Roberts	The 4see model - a physics approach to national accounts and GDP modelling
4.20pm	Aleksandra Aloric	Segregation of Traders at Auction Markets

Abstracts

Dmitri (Mitya) Pushkin - Rudolf Peierls Centre for Theoretical Physics, University of Oxford

Stirring by microorganisms

Billions of swimming microorganisms, each producing its own energy and interacting with other organisms, suspended solid particles and elastic fibers, via hydrodynamic, steric and chemical interactions form a heterogeneous, complex active medium that is ubiquitous to the life processes in water, air, soil and even ourselves. In this talk we focus on the (non-equilibrium) hydrodynamic fluctuations the microorganisms induce in the medium. One of their most significant consequences is the enhancement of the tracer particle diffusion and, hence, nutrient fluxes. We will describe different stirring mechanisms and strategies and their relative importance.

Philip Clemson - Lancaster University

Chronotaxic systems: complexity from stability

A new class of non-autonomous oscillatory systems is introduced. The defining characteristic of these systems is that in addition to having a stable amplitude they also have stable frequencies which can vary in time. However, despite having this inherent stability they are able to generate complex dynamics. Such behaviour has previously been treated as stochastic but we now show that it can be generated by simple deterministic systems. Hence, a wide range of systems exhibiting complex and stochastic-like dynamics, from living systems to low-temperature physics, can now be recognised as being deterministic.

<u>Fred Farrell - School of Physics, University of Edinburgh</u>

Collective behaviour in bacterial biofilms

Bacteria frequently form structures known as biofilms, collections of cells which grow in high density films on surfaces. Interactions between the cells are very important in this situation, and their collective behaviour leads to the formation of complex structures. The formation of these has usually been modelled using generalized Fisher equations which couple growth and diffusion of cells. However bacteria in biofilms often are not motile and only move by pushing each other. We use an alternative approach where the cells are modelled as a growing 'fluid', and derive some surprising results. I will also present some preliminary work on genetic drift and probability of fixation of advantageous mutations in such colonies, which has implications for the evolution of cooperation and the development of antibiotic resistance in these systems.

<u>Jean Boulton – Senior Visiting Research Fellow, Department of Social and Policy Sciences, University of Bath</u>

Physics and complex human systems - clarity or delusion?

[Abstract to follow]

<u>John Fry - Sheffield University</u>

Bubbles, antibubbles and elementary technical analysis via econophysics

In this paper we provide a unifying framework for a set of seemingly disparate models for shocks and bubbles in financial markets. Markets operate by balancing intrinsic levels of risk and return. Though seemingly trivial this simple observation is over-looked by many of the advanced techniques commonly used in mathematical finance. Of particular interest here is the subject of log-periodic precursors to financial crashes. Whilst our approach shares its origins in statistical physics - ours is a better physical model and thus is easier and more intuitive to calibrate to empirical financial data. We illustrate our model with timely applications to real-estate bubbles and to the on-going Euro-zone crisis. Our modelling approach is more flexible than the pre-dominant class of log-periodic models. In particular our class of models includes those used by academics and practitioners alike. In addition to proposing alternative models for bubbles and exogenous shocks we develop mathematical models for elementary technical analysis strategies - namely the identification of cycles and of price-level shocks.

<u>Simon Roberts – Arup</u>

The 4see model - a physics approach to national accounts and GDP modelling

"he 4see whole-economy framework harmonises multiple national accounting procedures within the constraints of the internationally accepted System of National Accounts (2008). The 4see model converts these views of the economy into a computational model to generate and test future scenarios. The model principle is that supply follows demand but is constrained in the short term by physical infrastructure. At the same time, capital formation, one component of final demand, grows the physical infrastructure so as to increase supply in the longer term. The model avoids economic and physical theories and relies on reconciled and integrated data. Results will be shown for the UK economy using historical data over 1990-2010 and scenario projection to 2030.

Aleksandra Aloric - King's College London

Segregation of Traders at Auction Markets

In this paper we investigate the possibility of spontaneous segregation of traders into groups when faced with having to choose among several markets. This is motivated by segregation effects seen in online auction tournaments, where they are signalled by persistent “loyalty” of groups of traders to certain markets. We set up a simple model for how traders make decisions in which market to trade and whether to act as buyer or seller, on the basis of accumulated scores for the various choices. We assume that markets have static, and very simple, rules for setting trading prices; in more realistic models also these market mechanisms could be allowed to evolve dynamically and thus adapt to the traders’ choices. Even in the simplest case of two markets and zero intelligence traders, we are able in numerical simulations to observe segregation effects below a critical value Tc of the temperature T; the latter regulates how strongly traders bias their decisions towards choices with large accumulated scores. It is notable that segregation occurs even though the traders are statistically homogeneous. Traders can in principle change their loyalty to a market, but the relevant persistence times become extremely long below Tc. Intriguingly, a segregated state of the trader population is stabilized by the presence of traders who are persistently trading at a market that is not globally optimal for them. This arises from the fact that, in order to make trading possible in any market, both buyers and sellers are required. Hence for the purpose of stability, some traders need to learn to “settle for less”, e.g. to buy at market with a pricing mechanism that favors sellers. We derive an analytical description of the system in the large trader population (thermodynamic) limit, which leads to a master equation for the distribution of the traders’ score vectors. Predictions from the resulting theory are in good qualitative agreement with simulation results, even though the latter are obtained for relatively small populations of traders.