Winter School on Mathematical Biology

February 15-18, 2010, La Habana, Cuba

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(ICREA & Universitat Autònoma de Barcelona, Spain)

(The lecture of Prof. J. A. Carrillo will likely be in spanish, depending on the audience)

Macroscopic and Kinetic Equations in Swarming and Chemotaxis

In these series of lectures I will review several models for the collective behavior of systems composed by many individuals. As a reference we will first discuss some swarming models proposed to describe some self-organized animal behaviors in fishes and birds for instance. Some typical principles of swarming will be described and minimal models derived. Continuum equations like kinetic or macroscopic equations appear when considering a large number of individuals and the corresponding mean-field limits and hydrodynamic equations will be treated. Some useful tools are distances between probability measures in which transport distances play an interesting role to connect to macroscopic models. At the macroscopic level, we will learn how to work with the transport distances in some typical examples. Classical chemotaxis models in which cells move due to a chemical response will be solved using this method and its use for some other aggregation equations in swarming will also be analysed.

Ecuaciones cinéticas y macroscópicas en "Swarming" y quimiotaxis

En esta serie de lecciones, haré un resumen del estudio de varios modelos del comportamiento colectivo de sistemas compuestos por muchos entes individuales. Como ejemplo de referencia, discutiremos algunos modelos del comportamiento de auto-organización en algunos animales como peces y pájaros, llamado "swarming". Los principios básicos del "swarming" darán lugar a modelos minimales para su descripción. Ecuaciones continuas de tipo cinética o macroscópicas se obtienen cuando el número de individuos es muy grande en lo que se conoce como límite de campo medio. Algunas herramientas matemáticas para estudiar dichos límites se analizarán como las distancias de tipo transporte entre medidas de probabilidad. Además, permiten conectar el estudio de dichas ecuaciones con ecuaciones macroscópicas. Modelos macroscópicos, entre ellos el de quimiotaxis en el que las células dirigen su movimiento hacia las regiones de mayor concentración de un cierto componente químico o algunos modelos de swarming, se pueden estudiar con dichas distancias.

Benoît Perthame

(Université P. et M. Curie, INRIA-Rocquencourt and Institut Universitaire de France, France)

Adaptive evolution : a population view

The two processes of mutations and selection, proposed by C. Darwin, can be written in mathematical words. In a very simple, general and idealized description, the environment can be considered as a nutrient shared by all the population. This alllows certain individuals, characterized by a 'phenotypical trait', to multiply faster because they are better adapted to use the environment. This leads to select the 'fittest trait' in the population. On the other hand, the new-born individuals undergo small variations of the trait under the effect of mutations. In these circumstances, is it possible to observ 'speciation' and to describe the dynamical evolution of the 'fittest' traits ?

We will give a class of self-contained mathematical models of such population dynamics and show that an asymptotic view allows us to formalize precisely the concepts of monomorphic or polymorphic populations. We can describe the evolution of the 'fittest traits' and various forms of branching points. We will also show that numerical solutions are consistant with individual based stochastic simulations.

Eventhough the model is very simple, its analysis relates to remarkable recent progresses of nonlinear analysis.

Marc Thiriet

(CNRS, Université P. et M. Curie and INRIA Rocquencourt, France)

Lecture 1 : Physiological flows – a macroscopic point of view with application to blood circulation and body's ventilation.

- Basic equations : mass and momentum conservation (Navier-Stokes equations).
- Main features : unsteady, developing, three-dimensional flows of Newtonian or non-Newtonian fluid in deformable pipes (distensible and collapsible ducts).

Lecture 2 : Physiological flows – a nano/microscopic point of view.

Biological conduit walls are living tissues that react to the stress field applied to them by flowing fluid (mechanotransduction) and adapt vessel lumen size accordingly. Additional behavioral equation must be coupled to correct the computational domain size predicted by the Navier-Stokes solution.

The Winter School on Mathematical Biology will be held at the “Salón 250 Aniversario de la UH” at the Varona Building inside the Campus (which is located at one side of the Faculty of Mathematics and Computer Science).

Schedule

Monday, February 15
13h30 - 13h45 : Welcome by the organizers
13h45 - 15h15 : J. A. Carrillo
15h15 - 15h30 : coffee break
15h30 - 17h00 : J. A. Carrillo

Tuesday, February 16
9h00 - 10h30 : M. Thiriet
10h30 - 10h45 : coffee break
10h45 - 12h15 : M. Thiriet
Lunch
13h45 - 15h15 : J. A. Carrillo
15h15 - 15h30 : coffee break
15h30 - 17h00 : J. A. Carrillo

Wednesday, February 17
10h00 - 11h30 : B. Perthame
11h30 - 11h45 : coffee break
11h45 - 13h15 : B. Perthame

free afternoon

Thursday, February 18
9h00 - 10h30 : M. Thiriet
10h30 - 10h45 : coffee break
10h45 - 12h15 : M. Thiriet
Lunch
13h45 - 15h15 : B. Perthame
15h15 - 15h30 : coffee break
15h30 - 17h00 : B. Perthame
