Preliminary program ICTP School "Collective Animal Behaviour"

Facultad de Física, Universidad de La Habana,
13 – 24 November, 2023

	FIRST WEEK					SECOND WEEK				
TIME	**MON 13**	**TUE 14**	**WED 15**	**THURS 16**	**FRI 17**	**MON 20**	**TUE 21**	**WED 22**	**THURS 23**	**FRI 24**
9:00-10:00	Welcome	Deborah Gordon	Deborah Gordon	Deborah Gordon	Deborah Gordon	Francesco Ginelli	Francesco Ginelli	Francesco Ginelli	Franceso Ginelli	Francesco Ginelli
10:00-10:30	**BREAK**									
10:30-11:30	Melanie Moses	Melanie Moses	Melanie Moses	Melanie Moses	Melanie Moses	Marcelo Magnasco	Marcelo Magnasco	Marcelo Magnasco	Marcelo Magnasco	Marcelo Magnasco
11:30-12:30	E. Altshuler & A. Reyes (CSC)	Alejandro Barro (FBio)	Roberto Alonso (FBio)	Patricia González (CIM)	Alejandro Lage (CSC)	P. De Castro/ A.Batista	S. Benas/ K. Verano	A.Vidal/ S. González	M. G. Cascallares	
12:30-14:30	**LUNCH**									
14:30-15:00	M. Madile	Poster session	M. Curbelo	Poster Session & Group picture 1	J. A. Guzmán	Brain storm on collected experimental data			Diploma thesis defense	
15:00-15:30	E. Ortega		A.Reyes		Awards ceremony for undergrad research					
15:30-17:00	Experiments in collective human behaviour								Group picture 2	

Deborah Gordon (Stanford University): She studies how ant colonies work without central control using networks of simple interactions, and how these networks evolve in relation to changing environments

Melanie Moses (University of New Mexico): She works on complex adaptive systems, Computational immunology, Biologically inspired computation and Swarm robotics

Marcelo Magnasco (Rockefeller University): He uses living beings as a source of inspiration for creating new mathematical descriptions of nature. Among other subjects, he studies dolphin communication in aquaria and in the wild.

Francesco Ginelli (University of Insubria): He works in the Physics of collective motion, from self-propelled particles to animal herds and flocks.

MINI-COURSES

Prof. Melanie Moses

COMPLEX ADAPTIVE SYSTEMS AND COLLECTIVE BEHAVIOUR

0. Introduction to Complex Adaptive Systems and Collective Behavior (Monday)
1. Agent based models of collective behavior
2. Emergent search behaviors in ants, immune systems and robots
3. Scalable networks for collective search, part 1 - why bigger is slower
4. Scalable networks for collective search, part 2 - why more is faster

Prof. Deborah Gordon

1. What is collective behavior and how does it work?
2. The regulation of foraging in harvester ants
3. The trail networks of turtle ants
4. The ecology of collective behavior: analogies across natural systems

Prof. Franceso Ginelli

Flocking, i.e., the collective motion exhibited by certain active matter capable of spontaneously breaking its rotational symmetry, is a ubiquitous phenomenon, observed in a wide variety of living systems and across various scales. Examples range from animal groups to bacterial colonies and cellular migrations down to the cooperative behavior of molecular motors and biopolymers at the sub-cellular level. In these lectures, I will present an overview of the theory of flocking active matter, discussing both microscopic agent based dynamics — such as the celebrated Vicsek model — and the corresponding hydrodynamic theories. I will mainly focus on universal properties, stressing the role of symmetries and conservation laws, but I will also attempt to discuss experimental realisation of collective motion. Preliminary lecture topics:

1. An introduction to active matter
2. The Vicsek model
3. Hydrodynamic theories
4. Experimental realizations of Collective motion
5. Beyond the Vicsek class

Prof. Marcelo Magnasco

Contents not yet available.

INVITED SEMINARS

Prof. Alejandro Barro (Biology Faculty, University of Havana)
Urania moth: Solitaire or collective insect?
Prof. Roberto Alonso (Biology Faculty, University of Havana)
The anuran calling repertoire: texts and contexts
Prof. Patricia González
Title not yet available
Prof. Alejandro Lage
Understanding human mobility from cellphone data: applications

SEMINARS BY PARTICIPANTS

Marco Madile Interaction and movement of vulnerable tortoises from Patagonia, Argentina
Ernesto Ortega Innovation-Obsolescence dynamics on networks.
Mariam Curbelo The anuran calling repertoire: further details (approximate title)
Alfredo Reyes How ants communicate through a mechanical barrier?
José Andrés Guzmán Non-Markovian SIR epidemic spreading with Weibull infection in networks with community structure
Pablo de Castro Collective Dynamics of Moving Organisms: The Statistical Physics of Self-Propelled Particles
Alberto Batista MacArthur's resource-competition model for large ecosystems with random species-resources couplings
Sabrina Benas Pattern separation in the hippocampus of mice
Kyrell Vann Verano Olfactory search with finite-state controllers
Anabelle Vidal Do Suburban Populations of Lizards Behave Differently from Forest Ones?
Saúl González Habitat selection of resident Turkey Vultures (Cathartes aura) in Cuba through GPS tracking data (Approximate title)
María G. Cascallares Title not yet available

SOME SEMINARS INCLUDING ABSTRACTS

Marco Madile

Interaction and movement of vulnerable tortoises from Patagonia, Argentina

Although it is one of the most commercialized species in the Argentinean illegal pet market, very little is known about the Chelonoidis chilensis tortoise in the wild. This fact, with the increasing habitat fragmentation caused by the recent introduction of cattle into the area, leads to the classification of its conservation status as 'vulnerable'. It is, therefore, essential to learn about their movement areas, their burrows, and their relationships within their community. The studied population lives at the southernmost edge of its dis tribution, near the city of San Antonio Oeste, Patagonia Argentina, which leads to them having a distinctive period of inactivity between April and October called brumation. As they are reptiles, they are considered mostly solitary, although very little is known about their social interactions. In this work, we studied the movement of six Chelonoidis chilensis tortoises during the whole year using an autonomous GPS navigation unit. We identified tortoises' areas of interest and pinpoint nocturnal burrow positions. By building proximity-based networks and bipartite networks of burrows and tortoises, we found very different connectivity patterns across the different behavioral periods of the year. The network with most links was observed during the mating period while connections decreased as approaching the brumation period. We found that some burrows were preferred, and also that tortoises spend consecutive nights in nearby burrows. But more interestingly, we observed that some daily encounters between tortoises were produced one to four days after or before sharing a refuge, revealing a possible pattern of social interaction and showing some evidence of memory in the studied population.

Ernesto Ortega

Innovation-Obsolescence dynamics on networks.

The classic relationship between innovation and obsolescence is Schumpeterian creative destruction, which is natural to consider retrospectively as a linear progression to the present. Yet, the branches of technology "trees" reconnect but those of biological evolution rarely do because there are many paths to a technological capability but a set of contingent ones to a species. We propose a model of generalized dynamics for how a population of agents innovate and render themselves obsolete to explore topologies ranging from trees to highly connected trusses. By developing analytic and numerical techniques, we find that larger branching ratios and trusses drive persistent innovation, revealing an important parameter for innovation-obsolescence dynamics.

José Andrés Guzmán

Title: "Non-Markovian SIR epidemic spreading with Weibull infection in networks with community structure"

This research investigates the influence of community structure on the susceptible-infected-recovered (SIR) epidemic process with a Weibull non-Markovian infection rate. Our study uncovers intriguing findings in both Markovian and non-Markovian modeling scenarios. In the context of Markovian modeling, we demonstrate that a robust modular structure plays a crucial role in reducing the overall epidemic size. However, through extensive numerical simulations on networks with community structure, we reveal that the effect of modular organization becomes less pronounced when negative aging processes are integrated into the system. Our results underscore the potential to control outbreaks by modifying either the network structure or the aging process. These findings reinforce the importance of considering non-Markovian modeling and community organization when devising strategies to mitigate the spread of epidemics.

Saúl González

Habitat selection of resident Turkey Vultures (Cathartes aura) in Cuba through GPS tracking data

The Turkey Vulture is a widespread New World species with healthy populations in Cuba. Urban and anthropic environments seem suitable habitats for the species, given the large amount of carrion and organic waste generated from human activity, and by providing for the occurrence of thermals vital for their soaring flight. Given their large home ranges, it is important to know in detail which natural or anthropic habitats are selected and whether there is a pattern of seasonal variation in habitat use. The objective of this research is to describe the range sizes and habitat selection of Turkey Vulture in dry (Nov-April) and wet seasons (May-Oct) in Cuba. In January 2021, 18 individuals were tagged with GPS devices (e-obs, IMU 25 g), from the western (n=6) and central region of Cuba (n=12), and the data generated until January 2022 were analyzed. Individual occurrence ranges were estimated for each season using the Minimum Complex Polygon method. Habitat selection was evaluated for individuals during foraging/resting and flight respectively. Points of presence and pseudo-absence to model the use of the different land cover classes and NDVI while accounting for individual and regional differences. This is the first habitat ecology and home range study of a resident and non-continental Turkey Vulture population through high temporal and spatial resolution data.

Pablo de Castro

Collective Dynamics of Moving Organisms: The Statistical Physics of Self-Propelled Particles

Imagine a flock of birds flying in splendid coordination or a swarm of bacteria moving in synchronized patterns. These collective behaviors are at the heart of Active Matter, a fascinating field in Nonequilibrium Statistical Physics that investigates the dynamics of self-propelled entities such as fish, cells, and artificial particles. This presentation aims to provide a brief overview of Active Matter and discuss how it has emerged as a framework to explore a diverse range of phenomena in many fields. In the process, I will briefly present some of our contributions to fundamental questions in Active Matter and applications in Epidemiology and Ecology. Our research seeks to uncover new physical principles and develop theoretical frameworks in Active Matter as well as to provide insights that could inform future conservation efforts, medical treatments, and fundamental research in biology.

Alberto Batista

MacArthur's resource-competition model for large ecosystems with random species-resources couplings

We solve MacArthur's resource-competition model with random species-resource couplings in the "thermodynamic" limit of infinitely many species and resources using dynamical path integrals à la De Domincis. We analyze how the steady state picture changes upon modifying several parameters, including the degree of heterogeneity of metabolic strategies (encoding the preferences of species) and of maximal resource levels (carrying capacities), and discuss its stability. Ultimately, the scenario obtained by other approaches is recovered by analyzing an effective one-species-one-resource ecosystem that is fully equivalent to the original multi-species one.

Sabrina Benas

Pattern separation in the hippocampus of mice

The hippocampus plays an important role in memory and spatial orientation. In particular, evidence suggests that the dentate gyrus (DG) prevents interference between similar memories by decorrelating CA3 representations, but the mechanism is unknown. Here we hypothesize that encoding is modulated by the demand for pattern separation in the DG-CA3 circuit. To explore this possibility, we performed calcium imaging recordings in CA3 with a Miniscope in a behavioral task that required pattern separation. Our preliminary results hint to a decrease in neuronal correlation in close objects than in far ones.

Kyrell Vann Verano

Olfactory search with finite-state controllers

Authors: Kyrell Vann B. Verano, Emanuele Panizon, Antonio Celani

Long-range olfactory search is an extremely difficult task in view of the sparsity of odor signals that are available to the searcher and the complex encoding of the information about the source location. Current algorithmic approaches typically require a continuous memory space, sometimes of large dimensionality, which may hamper their optimization and often obscure their interpretation. Here, we show how finite-state controllers with a small set of discrete memory states are expressive enough to display rich, time-extended behavioral modules that resemble the ones observed in living organisms. Finite-state controllers optimized for olfactory search have an immediate interpretation in terms of approximate clocks and coarse-grained spatial maps, suggesting connections with neural models of search behavior.

Anabelle Vidal

Do Suburban Populations of Lizards Behave Differently from Forest Ones?

Urbanization transforms natural ecosystems into novel habitats, which can result in negative consequences for biodiversity. Therefore, it is important to understand the mechanisms of maintenance of native species in urbanized environments, including behavior—which can act as a fast response to rapid environmental changes. We compared some behavioral traits between two suburban and two forest populations of Anolis homolechis. Direct observations of 779 individuals revealed that perch height was positively influenced by body size, but not by sex. Suburban individuals perched higher than forest ones, and even more so in the afternoon compared to the morning; a behavior that was not observed in forests populations. These differences might be due to a change from foraging activities in the morning to vigilance, display, and/or thermoregulation in the afternoon, promoted by suburban habitat conditions (e.g., higher predator abundance, open habitat structure, and urban heat). Video recordings of 81 focal individuals showed that males were more active than females (i.e., spending less time in stationary behavior and having a higher display rate), with no significant effect of habitat type. As some of our results diverge from previous studies on invasive anoles, we recommend extending comparative studies of urban and non-urban populations to other native Anolis.