



**European Research Council**  
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**Università di Roma Tor Vergata**  
*Dipartimento di Fisica*



## ***Seminar***

Tuesday, 3 July 2018 - h. 15:00

*Sala Struttura della Materia (Dipartimento di Fisica)*

### **Prof. Mogens H. Jensen**

*Niels Bohr Institute  
University of Copenhagen  
Denmark*

## **“Coupled Oscillations in Biology: Arnold Tongues and Mode Hopping”**

### ***Abstract***

Oscillating patterns with periods of 2-5 hours have been observed for transcription factors in single cells. The oscillations appear as a response to DNA damage and other induced stresses. We have identified the central feed-back loops leading to oscillations and formulated genetic networks in terms of mathematical equations. By applying an external periodic protein signal, it is possible to lock the internal oscillation of a transcription factor to the external signal. We have observed that the two signals lock when the ration between the two frequencies is close to basic rational numbers [1] which can be mapped out as Arnold tongues. When the tongues start to overlap we may observe mode hopping and chaotic dynamics in the concentration of proteins [1,2]. We investigate how this influences gene productions through stochastic simulations by Gillespie algorithm. We have observed similar phenomena in neuron dynamics [3].

[1] M.H. Jensen and S. Krishna, "Inducing phase-locking and chaos in cellular oscillators by modulating the driving stimuli", FEBS Letters 586, 1664-1668 (2012).

[2] M.L. Heltberg, R. Kellogg, S. Krishna, S. Tay and M.H. Jensen, "Noise-induced NF-kB Mode Hopping Enables Temporal Gene Multiplexing" Cell Systems 3, p. 532–539 (2017).

[3] R. Rasmussen, M.L. Heltberg, M.H. Jensen "Extracellular Ion Concentrations Modulate Neuronal State Transitions Governed by Chaotic Dynamics", Cell Systems 5, 591-603 (2017).

**ERC Advanced Grant (N. 339032) “NewTURB”**  
**(P.I. Prof. Luca Biferale)**

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