Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **4201** Type: **Oral Competition (Undergraduate Student) / Compétition orale (Étudiant(e) du 1er cycle)**

(UG*) Spreading of Chaos in Systems with Long Range Interactions

Monday, May 27, 2024 4:15 PM (15 minutes)

Chaotic classical systems exhibit extreme sensitivity to small changes in their initial conditions. In a spin chain, chaos can be tracked not only in time, but in space. The propagation of small changes in the initial conditions results in a "light cone"bounding the spatial region and time interval when the trajectories have diverged. For nearest-neighbour interactions, the light cone produced is linear, defining a "butterfly velocity" that characterizes the speed at which chaos propagates. Realistic systems are more complicated, and can include interactions beyond immediate neighbours. We examine how more realistic, longer-range interactions affect the spread of chaos in spin chains, and how the light cone is modified by their presence. Using a classical analogue of the out-of-time-ordered correlator (OTOC), we measure the decorrelation of the two spin chains in time and space, modifying the equations of motion to incorporate further neighbor interactions. We explore two cases: exchange interactions with exponential and power-law decays. For the exponentially decaying case, we find the slope of the front at long times is modified even for very small interactions, but there is a critical decay constant below which we recover the nearest neighbour result. For the power-law case, the front becomes logarithmic at long-times, independent of the power-law exponent. We demonstrate that this behavior emerges from the superposition of nearest-neighbor linear cones with the initial disturbances giving rise to an envelope defining the front of the modified light cone. Finally, we discuss potential future directions in understanding chaotic behaviour in higher-dimensional classical systems and realistic interaction terms, such as anisotropy.

Keyword-1

Chaos

Keyword-2

Spin Dynamics

Keyword-3

Spin Chains

Primary authors: SABRA, Sareen (University of Windsor); Dr RAU, Jeffrey (University of Windsor)

Presenter: SABRA, Sareen (University of Windsor)

Session Classification: (DCMMP) M3-8 Quantum Materials I | (DPMCM)

Track Classification: Technical Sessions / Sessions techniques: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)