- <u>Mini workshop related to dynamical systems and celestial mechanics</u>

August 6th
場所：青葉山数学棟 209 講義室
時間：13:00 – 15:30

13:00—13:45
Makoto Hattori (Astronomical Institute, Tohoku University)

Title:
Seeking for the hidden truth behind the modern mystery in cosmology: The Hubble tension.
" Steckt der liebe Gott in Detail?"

Abstract:
I guess most of you know that our universe is expanding.　This is observationally supported by the fact that all galaxies move away from us, and the recession velocity of a galaxy is proportional to the distance to the galaxy from us.　This is known as Hubble's law. The proportional constant is referred to as the Hubble constant.　Measuring the Hubble constant from the accurate measurement of Hubble's law is called the direct method of Hubble constant measurements. Because of the intrinsic difficulties of measuring the distance toward the celestial objects in astronomy, the reported values of the Hubble constant based on the direct method have long been accompanied by large systematic errors.　However, thanks to long-standing efforts by astronomers, the accuracy of the Hubble constant deduced by the direct method has been improved drastically. The reported Hubble constant by the most reliable measurements is 73.04+-1.04 km/s/Mpc, where megaparsec (Mpc) is the astronomical distance unit and is 3.09*10^24 cm. In parallel, thanks to the revolutionary progress of the measurements of intensity fluctuations and the polarization pattern imprinted in the Cosmic Microwave Background radiation (CMB), super-accurate values of the Hubble constant have been reported by multiple CMB experiments. The CMB is the relic radiation of the Big Bang.　Because the physical processes that imprint a signal on the CMB are well described by linear theory, the methods to extract the Hubble constant from the CMB observations have a reliable physical background. The method to extract the Hubble constant from the CMB observations is referred to as the indirect method. The reported Hubble constant is 67.4+-0.5 km/s/Mpc. The discrepancy of the reported values of the Hubble constants deduced from the direct methods and the indirect methods is statistically significant and is called the Hubble tension.

We are now studying whether the dark energy, which has a physical property beyond astronomers' common knowledge, might resolve the Hubble tension. The dark energy is the dominant constituent of matter in the current universe, which was introduced to explain the observational evidence of the accelerated expansion of the universe. One of the candidates for dark energy is the scalar field. The energy density of the scalar field, rho, is described by the sum of the kinetic energy, K, and the potential energy, V. On the other hand, the pressure of the scalar field, P, is described by the kinetic energy minus the potential energy. Conventionally, the equation of state of the dark energy, that is scalar field in this talk, is parametrized by P=w *rho. We are trying to fit all available observational results, allowing the time evolution of w, and are finding that the w of the current universe must be less than -1 and might oscillate across -1, although these are very preliminary results. If the dark energy is the scalar field, w=(K-V)/(K+V), w should stay larger than -1 since K must have a positive value for astronomers. To realize w<-1, the kinetic energy of the scalar field must be negative.

I was inspired by Prof. Chiba's lecture, where he mentioned that a wave is possible to propagate deep inside the potential well as a solution of the Schrödinger equation. If my understanding is correct, the kinetic energy of the wave propagating inside the potential well should be negative since the total energy of the wave must be conserved. If so, it may provide a great hint to resolve the Hubble tension and the physics of the dark energy. I believe that sharing this information with mathematicians could be very fruitful to advance the situation. "Is God in the detail?". At present, God Only Knows.

14:00—14:45

Georgi Medvedev (Department of Mathematics, Drexel University)

Title:

The Kuramoto Model on the Sierpinski Gasket

Abstract:

The hierarchical organization of real-world networks, such as power grids or the Internet, can be effectively modeled by self-similar graphs. To explore the relationship between the self-similar structure of the network and the qualitative dynamics it generates, we study the Kuramoto model of coupled phase oscillators on graphs approximating p.c.f. fractals.

We find an interesting connection between the topology of the underlying fractal and the attractor of the dynamical model. Specifically, we show a one-to-one correspondence between the homotopy classes of continuous functions on the fractal and the stable equilibria

of the Kuramoto model.

15:00—15:30

Haozhe Shu (AIMR, Tohoku University)

Title:

Analysis of pitchfork bifurcation and symmetry breaking in the restricted three-body problem

Abstract:

The spatial restricted three-body problem (RTBP), which describes the motion of an infinitesimal body (spacecraft or asteroid) under the gravitational influence of two primaries, serves as a foundational model in celestial mechanics. In this talk, a quantitative analysis of pitchfork bifurcation and associated symmetry breaking around libration points in the RTBP is presented. By introducing a unified trigonometric series-based framework, bifurcations of both periodic/quasi-periodic and transit/non-transit orbits are captured from the perspective of coupling-induced bifurcation mechanisms. This talk is based on a joint work with Dr. M. Lin.