**Project title:**

**INFORMATION-THEORETIC ENTROPIC MEASURES IN COMPLEX SYSTEMS –**

**THEORY AND APPLICATIONS**

**Project acronym: ITEMICS**

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**PARTNER INSTITUTIONS:**

**From Austria:**

- Section for Science of Complex Systems, Center for Medical Statistics, Informatics and Intelligent Systems, Vienna, Austria.

**From Serbia:**

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**PROJECT DESCRIPTION:**

Over the past decades, there has been an unprecedented interest in statistical physics of complex systems that are typically non-additive, non-extensive in the Boltzmann-Gibbs framework, and that exhibit long-lived non-Boltzmann stationary states accessible to observations. These systems are usually characterized by long-range interactions and/or correlations, path dependence, and non-exponential phase-space growth. They are studied using information theory, non-equilibrium thermodynamics, and large deviation theory, and can be analyzed using generalized thermostatistics

derived from additive and non-additive generalizations of the Boltzmann-Gibbs entropy. This project aims to explore intriguing relationships between statistical physics and information theory and to re-examine the role of generalized entropies and generalized thermostatistics in complex system modeling. We will mainly focus on axiomatic approaches, which are compelling tools and could serve as an invaluable way to analyze these relationships. The most prominent ones – strongly pseudo-additive entropies – can be derived from generalized Shannon-Khinchin axioms and Shore-Johnson axioms. On the other hand, the introduced InforCer measures quantify information, certainty, and inaccuracy within the same framework and define an entire family of measures with a defined mathematical and information-theoretic structure. This research aims to answer the following questions: what is information, what are the essential properties that information should satisfy, and what is the general mathematical form of information measures that appears in quantum information theory, information geometry, statistics, and applied sciences? This framework will pay special attention to the applicational aspects of the information measures to mean-field spin systems, systems with emergent structures, non-equilibrium systems, multifractals, disordered systems, and chaotic systems.

The full understanding of the mathematical structure of generalized entropies requires the knowledge of related mathematical fields such as Karamata's theory of regular variation, fractional calculus, algebraic topology and combinatorics. To this end, the project will be divided into the following tasks:

- Axiomatic characterization of generalized entropies, analysis of their thermodynamic aspects and their applications for complex systems modeling;
- Characterization of generalized entropies using fractional calculus, Karamata's theory of regular variation, and theory of q-differences;
- The applications of algebraic topology, combinatorics, and topological data analysis for complex systems modeling and characterization of generalized entropies;
- Exploration of the possibilities for applications of generalized entropies in the fields of bifurcation theory of ordinary differential equations.

The fields of generalized entropies and complex systems modeling are emergent but still not sufficiently developed in the region. To disseminate the aforementioned fields in a way that values multidisciplinarity and multiculturalism, the project will support the promotion of the field of generalized entropies for complex systems modeling to a broad range of scientists, fostering collaboration on complex systems research among communities and encouraging early-career researchers and underrepresented groups to disseminate their results in the field of complex systems.