# SOE 4: Dynamics and Scaling of Cities and Societies

Time: Thursday 10:00–11:00 Location: H3

**Topical Talk** SOE 4.1 Thu 10:00 H3

**Felix Auerbach and Zipf's Law for Cities** — •Diego Rybski[1,2,3] und Antonio Ciccone[4] — [1]Potsdam Institute for Climate Impact Research - PIK, Member of Leibniz Association, P.O. Box 60 12 03, Potsdam 14412, Germany — [2]University of California Berkeley, Department of Environmental Science, Policy and Management, 130 Mulford Hall #3114, Berkeley, CA 94720, USA — [3]Complexity Science Hub Vienna, Josefstädterstrasse 39, A-1090 Vienna, Austria — [4]Department of Economics, University of Mannheim, Mannheim, Germany

Power-law city size distributions are a statistical regularity researched in many countries and urban systems. In this history of science treatise we reconsider the paper by F. Auerbach published in 1913. Therefore, we review his empirical analysis and find (i) that a constant absolute concentration (AK), as introduced by him, is equivalent to a power-law distribution with exponent $\approx 1$, (ii) the value of his AK relates to the size of the largest city, and (iii) the specific concentration (SpK), as also introduced by Auerbach, relates to the number of cities. We further investigate his legacy as reflected in citations and find that important follow-up work does give proper reference to his discovery – but other does not. A bibliographic analysis shows that almost all city-related works that cite Auerbach 1913 also cite Zipf 1949. However, only approximately 20 % of works citing Zipf 1949 also cite Auerbach 1913. To our best knowledge A.J. Lotka 1925 was the first to describe the power-law rank-size rule. Consequently, we suggest to use "Auerbach-Lotka-Zipf law" (or "ALZ-law") instead of "Zipf's law for cities".

**Topical Talk** SOE 4.2 Thu 10:30 H3

**Envy-induced class separation in societies of competing agents** — •Claudius Gros — Institute for Theoretical Physics, Goethe University Frankfurt

Everything is relative. This holds for Darwinian selection, which is based on relative fitness advantages, and today's social success and fairness criteria. The desire to compare own's own incomes and resources with that of others is the basis of envy. In game theoretical settings, envy is described by a psychological component, in addition to the monetary payoff function. We find that envy leads to a phase transition in societies of competing agents. Below the transition, most agents play pure strategies which follow from occupying the most yielding options. When approaching the transition, an increasing number of agents play mixed strategies, which eventually merge to a single encompassing mixed strategy played by a large number of agents, the lower class. All the while, upper-class agents continue to play high-rewarding pure strategies. Considering the Ultimatum game with envy, we estimate the strength of human envy from the respective laboratory results. One finds that envy is strongly relevant for humans societies.

C. Gros, "Collective strategy condensation: When envy splits societies", Entropy 23, 157 (2021).

C. Gros, "Self induced class stratification in competitive societies of agents: Nash stability in the presence of envy", Royal Society Open Science 7, 200411 (2020).