

## Physical interpretation of historical phenomena

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The exceptionally wide and universal scientific interests of Vadim Alexandrovich Malyshev included the interpretation of the structure and dynamics of society on the grounds of theoretical physics. In particular, they were presented at the Russian conferences on sociophysics in 2015 and 2018. [1,2]. Here we provide an essay on the interdisciplinary application of physical ideas in the description of some historical events.

The fundamental physical influence in the history of mankind is the flow of solar energy to the Earth surface. Slow fluctuations of the *solar constant* (ca. 1370 W/m<sup>2</sup>, changes up to 1% in the scale of centuries) – the Roman maximum of the I-II cent. AD, the Roman minimum of the VI-VII AD, the Maunder minimum of the 17th century, and others – coincide with major historical phenomena: respectively, the flourishing and collapse of Ancient Rome, the "Little Ice Age" with a couple of wars and revolutions in Europe, etc.

The emergence of feudal state fragmentation, or *feudal revolution*, in the 11th-12th centuries AD in Western Europe, Kievan Rus and medieval China (that time only loosely connected), not yet interpreted in physical terms, coincides with the global warming of the 10th-12th centuries, or the Medieval Climatic Optimum. In the agent-based modeling of this process, the stationary flow of 'energy' (conditional 'wealth') into the set of agents ('feudal lords') able to 'fight' and 'acquisitions', generated their hierarchy according to the wealth. The abrupt doubling of the energy flow led to the temporary equalization of agents, followed by a gradual restoration of the hierarchy in a following stationary flow. The weakening of central power and the fortification (*encastellation*) in Western Europe during this period can be explained by the fast enrichment of large landowners and the intensified struggle between them [3].

The another non-classical, though accepted by many historians observation (still without physical interpretation but with several mathematical models), is the *hyperbolic* dynamics of the growth of the Earth's population in the 15th – 20th centuries AD [4]. Basing on historical, demographic and physical data we suggest an analogy of such dynamics with the dynamics of critical parameters in physical systems near the phase transition point. In this case, the equivalent of phase transition is 'condensation' of initially hostile political entities on a national and then on a global scale. The hyperbolic dynamics of human growth was changed to a linear one after the formation of a unified world economic system in the middle of the 20th century [5].

One more non-classical array of historical data form the durations of monarchical rule in a number of different states and regions, modeled by Weibull distributions [6]. Their similarity with the mortality curve (see Figure) allows to suggest that the term of the monarch's reign could be determined by the "lifetime" of the supporting structures, i.e. *king's court*. The announced topics will be discussed in the framework of interdisciplinary historical research.

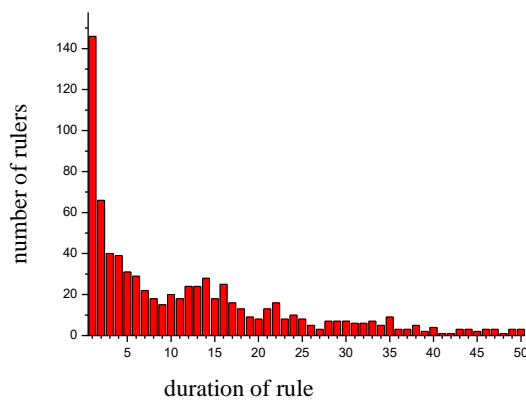
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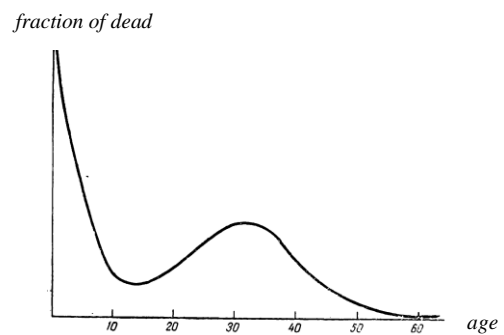
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(a)



(б)

Figure. (a) Duration of one-man rule (Ancient Rome, England, France, Russia, China; total 766 rulers). (b) The neolithic mortality curve [7].