

Verifications of the origin of 1/f noise -Earthquakes, solar flare, and variable stars

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We have recently proposed a simple model of 1/f fluctuations (pink noise) based on the amplitude modulation of accumulated frequency waves (AMAF). We challenge to what extent this mechanism can be universal among the variety of 1/f fluctuations reported so far. An inevitable condition of our AMAF proposal is the existence of the demodulation (DM) process for the appearance of 1/f fluctuations. This condition can be a merkmal indicator for verifying the AMAF proposal. The frequency accumulation can spontaneously arise in the cases of a) synchronization, b) resonance, and c) Infrared divergence. We explore each of them below. We first show that the earthquake time sequence of 50 years of USGS global data shows 1/f fluctuations in its power spectrum density (PSD) if we limit the magnitude, although the whole data does not. Further, ignoring the magnitude information, the earthquake occurrence time sequence shows much clear 1/f fluctuations. According to the AMAF proposal, there must be resonant modes of Earth that cause 1/f fluctuations. We identify these modes as the Earth's free oscillation that is always excited. We found the accumulation and the superposed waves of such eigenfrequencies show 1/f fluctuations. This free oscillation may be the origin of the earthquake 1/f fluctuations. On the other hand, the demodulation (DM) mechanism should be the fault rupture. This relatively low-energy phenomenon is consistent with the fact that the 1/f fluctuations appear in low-energy earthquake events. Further, we found the 1/f fluctuations in the Earth's rotation speed, which the Earth's free oscillation may cause. Second, we show that the solar flare time sequence of 20 years RHESSI data shows 1/f fluctuations in its power spectrum. Many other time sequences of the phenomena, such as the solar wind, cosmic rays, and NO_3^- deposition on the Antarctic ice sheet (Mochizuki et al. arxiv.2209.11330), also show 1/f fluctuations. According to the AMAF proposal, we suspect the existence of resonant modes of the Sun that cause the above 1/f fluctuations. We identify these modes as the solar five-minute oscillation. We found the accumulated frequency difference distribution and that the superposed waves of such eigenfrequencies show 1/f fluctuations. This may be the origin of the various solar 1/f fluctuations. On the other hand, the demodulation (DM) mechanism should be the magnetic reconnection that often triggers solar activities. Third, we show that variable star light curve time sequence (AAVSO) shows 1/f fluctuations in its power spectrum. According to the AMAF proposal, there must be any synchronization mechanism in the variable stars that cause the 1/f fluctuations. We construct a model of the variable star as the coupled many convections expressed as the coupled Lorentz models. We show that this model naturally creates 1/f fluctuations according to the synchronization of convections. Thus, the origin of various 1/f fluctuations can be simple amplitude modulation (AMAF) and demodulation (DM) processes rather than any elaborate theories of statistical mechanics. If time allows, we can show more analysis: infrared divergence, volcano eruption, orchestra music, iceberg sound, and water harp caves.