Statistical property of earthquakes network: active and passive points

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Abstract: Recent results in complex systems have indicated that network theory, which is known as graph theory in mathematics, is a powerful method to handle unsolved complex problems. Earthquakes manifest spatio-temporal complex behavior that can be studied using complex networks. It is so essential for these studies to construct an appropriate network. Then we use the statistical mechanics to study the property of such a network.

We propose a new combination method of Abe - Suzuki method [1] and Telesca - Lovallo method [2] for constructing earthquakes network. We divide a geographical region into small square cells that these cells cover the entire region without any overlapping. If an earthquake with any value of magnitude occurs in a cell, we identify it as a vertex of a network. Then for connecting links between vertexes we use the visibility condition. Indeed in our method two events are connected to each other if visibility condition holds true between them.

For Iran and California earthquakes we divide the longitudinal and latitudinal ranges into cells (cell sizes changes from $4km$-$220km$). We show that the constructed networks are scale free and theirs degree distribution obey the q-exponential function which is used in non-extensive statistical mechanics [3]. The diagram of q parameter in terms of the cell size has a peak at $31km$ for Iran and $44km$ for California. Due to dependence of network characteristics on each other for cell sizes less than peak size, only one of the cell sizes is enough to describe the earthquakes network. We found that such model network results in both the Gutenberg-Richter and Omori laws.

Also we find the universal behavior of links and nodes number with time for same areas and same resolution of Iran and California earthquakes. This behavior is power law and similar to Omori law but there are differences between them.

Furthermore, analogy to Darooneh- Lotfi [4] by using the concept of PageRank, we find the passive and active points in the geographical region of Iran.

Keywords: Statistical Mechanics, Earthquake Network, PageRank

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