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REVIEW

One-Dimensional Dynamical Modeling of Earthquakes: A Review

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ABSTRACT

Studies of the power-law relations of seismicity and earthquake source parameters based on the one-dimensional (1-D) Burridge-Knopoff's (BK) dynamical lattice model, especially those studies conducted by Taiwan's scientists, are reviewed in this article. In general, velocity- and/or state-dependent friction is considered to control faulting. A uniform distribution of breaking strengths (i.e., the static friction strength) is taken into account in some studies, and inhomogeneous distributions in others. The scaling relations in these studies include: Omori's law, the magnitude-frequency or energy-frequency relation, the relation between source duration time and seismic moment, the relation between rupture length and seismic moment, the frequency-length relation, and the source power spectra. The main parameters of the one-dimensional (1-D) Burridge-Knopoff's (BK) dynamical lattice model include: the decreasing rate (r) of dynamic friction strength with sliding velocity; the type and degree of heterogeneous distribution of the breaking strengths, the stiffness ratio (i.e., the ratio between the stiffness of the coil spring connecting two mass elements and that of the leaf spring linking a mass element and the moving plate); the frictional drop ratio of the minimum dynamic friction strength to the breaking strength; and the maximum breaking strength. For some authors, the distribution of the breaking strengths was considered to be a fractal function. Hence, the fractal dimension of such a distribution is also a significant parameter. Comparison between observed scaling laws and simulation results shows that the 1-D BK dynamical lattice model acceptably approaches fault dynamics.

Key words: One-dimensional Burridge-Knopoff's dynamical lattice model, Scaling laws, Earthquake rupture, Seismicity

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1. INTRODUCTION

Since the end of the 19[th] century, several self-similar properties of spatial distributions and temporal variations of earthquakes have been found. These properties are generally characterized by a power-law function. Omori (1895) observed the temporal variation in the number n(t) of aftershocks following a mainshock in the form: $n(t) = c/t^p$, where c is a constant and p is the scaling exponent and is close to 1 for most observations. Utsu (1961) generalized Omori's law to a form of $n(t) = c/(1+t)^p$. Gutenberg and Richter (1944) reported a frequency-magnitude (FM) scaling law of earthquakes in the form: logN = a - bM, where M is the earthquake magnitude and N is the cumulative or discrete frequency of events with magnitudes ≥ M. Ekstrom and Dziewonski, (1988) stated that the seismic energy, E_s, released during an earthquake relates to M in the form: $\log(E_s) \sim \xi M$, where ξ is 1 for earthquakes with $M_s < 5.3$ and 3/2 for those with $M_s > 6.8$. Hence, there is a power-law function between N and E: $N \sim E_s^{-B}$, where $B = b/\xi$. Kanamori and Anderson (1975) reported a power-law function for seismic moment, M_o, and rupture length, L, of earthquakes in the form: $M_o \sim L^3$. This relation is commonly considered to hold up for a wide range of events (Hanks 1977). However, for Japanese earthquakes, Shimazaki (1986) reported a change in scaling from $M_o \sim L^3$ to $M_o \sim L^2$ occurring at the point where $M_o = 7.5 \times 10^{25}$ dyne-cm. Aki (1992) and Romanowicz (1992) also reported such a change for worldwide and California earthquakes. However, from more than

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