Renormalized source parameters on fractally rough faults

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Nonplanar properties of faults are considered to contribute to the fault source parameters [Andrews 1976, Scholz 2002]. However it is poorly studied compared to the comprehensive studies of planar fault models [Ando Yamashita 2007]. Partial reason is that the numerical cost of nonplanar faults is quite higher than the planar modelings. We proposed the O(N) method (FDP=H-matrix) in another presentation and solved this cost problem. So, we study the nonplanar effect of the fault using this method and report the result. We mainly focus on the fractal fault roughness universally observed in natural faults [Scholz 2002, Renard et al 2013].

The effect of the roughness is studied experimentally [Ohnaka 2002] and theoretically [Gold'stein and Mosolov 1991, Horvath Herrmann 1992], but those conclusions do not coincide with each other. The effect of fault roughness is well studied by the experiment of [Ohnaka 2002] and he found the critical slip scaling distance (Dc) linearly depends on the lower cutoff wavelength of the fractal scaling. This Dc scaling is consistent with the expected behavior of fault [Ide Aochi 2013]. However, the past renormalization group approach of the fractal fault predicted the different scaling of Dc [Gold'stein and Mosolov 1991]. The scaling exponent is smaller than the 0.5 (roughly 0.23 if we use the observed Hurst exponent 0.77 [Renard et al. 2013]) and quite weaker than the linear dependence as observed in experiments. Also, some theory asserts that terminal velocity becomes slower and slower if the earthquake becomes large [Horvath Herrmann 1992] but this prediction is inconsistent with the experiment [Ohnaka 2002] and simulations [Ide Aochi 2004, Dunham et al. 2011] It asserts the discrepancy of the interpretation from the actual physics behind the experiment and the lack of the theory. However, the studied parameter is still limited and the system size is not so large to discuss those scaling behavior.

Therefore, we present some results on dynamic rupture simulations on fractal rough faults using O(N) method. The current result is as follows. Dynamic rupture apparently propagates at sub-shear velocity but looks not so slower than the theoretical prediction; In some parameters where the crack with slip weakening friction does not stop spontaneously, we observed the subshear velocity of crack propagations. However, the terminal velocity looks faster than the theoretical prediction. Therefore, we constructed the estimation of the terminal velocity for the case where the Griffith energy becomes linearly depends on the crack sizes. This estimation predicts the the sub-shear terminal velocity. It looks consistent with our result and [Ide Aochi 2013]. The result of Dc scaling will be also discussed in the presentation.

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