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Poisson goes, random walker comes: Explaining the power-law distribution of the durations of stable-polarity intervals

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In contrast to the predominant paradigm, recent studies indicate that the lengths of polarity intervals do not follow Poisson statistics, not even if non-stationary Poisson processes are considered. It is here shown that first-passage time (FPT) statistics for a one-dimensional random walk provides a good fit to the polarity time scale (PTS) in the range of stable polarity durations between 10 ka and 3000 ka. This fit is achieved by adjusting only a single diffusion time T, which comes to lie between 70 ka and 100 ka depending on the PTS chosen. A physical interpretation, why the FPT distribution of a random-walk process applies to the geodynamo, could relate to a balance between decay of stochastic turbulence and generation of the magnetic field. A simplified picture assumes the field generation to occur from a collection of 10-100 statistically independent dynamo processes, where each is described, e.g., by a Rikitake equation in the chaotic regime. An interesting feature of the random walk model is that it naturally introduces an internal variable, the position of the walk, which could be linked to field intensity. This connection would suggest that the variance of field intensity increases with the duration of the polarity interval. It does not predict a strong correlation between the strength of the paleofield and the duration of a chron. A further strength of the random walk model is that superchrons are not outliers, but natural rare events within the system. The apparent non-stationary nature of the geodynamo can be interpreted in the random walk model by a continuous shift in the governing parameters, and does not require major restructuring of the internal geodynamo process as in case of the Poisson picture.