Mean First Reaction Time for non-Markovian Random Walkers to React at Imperfect Targets

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From chemical dynamics one knows that chemical reactions are usually subjected to some reaction rate, k_0, that controls the speed of the reaction it self. This makes it so that, when dealing with chemical reactions, one must consider two stages in the reaction dynamics; one, physical, that considers the movement of the reactants to get within reactive distance and another, rather chemical, that corresponds to the time needed for the reaction to take place once the two reactants are at reactive distance. Recent work has been made to determine the Mean First Reaction Time (MFRT) for Markovian Random Walkers (RWs) to react at a reactive region. However, most physical RWs are actually non-Markovian, i.e., their movement at time t will depend on the trajectory they have made up to then, thus displaying what we call memory effects. This memory effects can be seen, for example, in beads moving inside fluids that do not relax to equilibrium instantly. In these fluids one movement in one direction will change the pressure of the fluid around the bead and thus conditioning the next movement to the new pressures exerted by the fluid on the bead. A general theory for non-Markovian RWs is hard to develop since we mathematically cannot write differential equations that incorporates these memory effect. Here, we derive the expression for the MFRT to react at an imperfect target and closed expressions for the first and second moments of the propagator of the particles that have reacted at the target. Then we study the case of weakly non-Markovian RWs, i.e., the memory effects are weak. We finish by finding the leading dependence on the reaction rate, k_0, for weakly reactive non-Markovian RWs where we verify that the exponents previously known are wrong for RWs displaying strong memory effects.