Flying randomly in $\mathbb{R}^d$ with Dirichlet displacements

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Random flights in $\mathbb{R}^d,d\geq 2,$ with Dirichlet-distributed displacements and uniformly distributed orientation are analyzed. The explicit characteristic functions of the position $\underline{\bf X}_d(t),\,t>0,$ when the number of changes of direction is fixed are obtained. The probability distributions are derived by inverting the characteristic functions for all dimensions d of $\mathbb{R}^d$ and many properties of the probabilistic structure of $\underline{\bf X}_d(t),t>0,$ are examined.

If the number of changes of direction is randomized by means of a fractional Poisson process, we are able to obtain explicit distributions for $P\{\underline{\bf X}_d(t)\in d\underline{\bf x}_d\}$ for all $d\geq 2$. A Section is devoted to random flights in $\mathbb{R}^3$ where the general results are discussed.

The existing literature is compared with the results of this paper where in our view the classical Pearson's problem of random flights is resolved by suitably randomizing the step lengths. The random flights where changes of direction are governed by a homogeneous Poisson process are analyzed and compared with the model of Dirichlet-distributed displacements of this work.

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