
## Urna Basu

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Theoretical Sciences

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## Guidance of Students/Post-Docs/Scientists

**a) External Project Students / Summer Training**

1. Durgesh Ajgaonkar; Inertial active particles; IISER Pune
2. Aniket Zodage; Coupled passive-active particle system; IISER Pune

## Teaching

1. Autumn semester; Stochastic Process and numerical Methods; PhD; 13 students

## Publications

**a) In journals**

1. Ion Santra, **Urna Basu** and Sanjib Sabhapandit, *Run-and-tumble particles in two dimensions under stochastic resetting conditions*, Journal of Statistical Mechanics: Theory and Experiment, 2020, 113206, 2020

### Talks / Seminars Delivered in reputed conference / institutions

1. IISc Physics Colloquium; Nov 27, 2020; online
2. Edinburgh Statistical Physics Seminar; Jan 13, 2021; online
3. RRI TP seminar; Mar 23, 2021; online

## Scientific collaborations with other national / international institutions (based on joint publications)

1. Sanjib Sabhapandit, Raman Research Institute. Sl. No. 1, National

## Areas of Research

Statistical Physics: active particle dynamics, nonequilibrium fluctuation response, nonequilibrium critical phenomena

Active particles are self-propelled agents which consume energy from environment and convert it into directed motion. Apart from various interesting collective phenomena, active particles also show a lot of novel behaviour even at the level of individual particles. Recently I have been focussing on the effect of stochastic resetting on active particle dynamics. In two recent publications we have studied the dynamics of Run-and-Tumble Particles (RTP) and Active Brownian particles (ABP) in the presence of stochastic resetting.

In the first work we study the effect of stochastic resetting on a run and tumble particle (RTP) in two spatial dimensions. We consider a resetting protocol which affects both the position and orientation of the RTP: with a constant rate the particle undergoes a positional resetting to a fixed point in space and orientation randomization. We compute the radial and x-marginal stationary state distributions and show that while the former approaches a constant value as r  0, the latter diverges logarithmically as x  0. On the other hand, both the marginal distributions decay exponentially with the same exponent far away from the origin. We also study the temporal relaxation of the RTP and show that the position distribution undergoes a dynamical transition to a stationary state. We also study the first passage properties of the RTP in the presence of the resetting and show that the optimization of the resetting rate can minimize the mean first passage time. We also give a brief discussion on the stationary states for resetting to the initial position with fixed orientation.

In another recent work we have studied the position distribution of an active Brownian particle in the presence of stochastic resetting in two spatial dimensions. We consider three different resetting protocols : (I) where both position and orientation of the particle are reset, (II) where only the position is reset, and (III) where only the orientation is reset with a certain rate r. We show that in the first two cases the ABP reaches a stationary state. Using a renewal approach, we calculate exactly the stationary marginal position distributions in the limiting cases when the resetting rate r is much larger or much smaller than the rotational diffusion constant DR of the ABP. We find that, in some cases, for a large resetting rate, the position distribution diverges near the resetting point; the nature of the divergence depends on the specific protocol. For the orientation resetting, there is no stationary state, but the motion changes from a ballistic one at short-times to a diffusive one at late times. We characterize the short-time non-Gaussian marginal position distributions using a perturbative approach.

## Plan of Future Work Including Project

1. Presently we are studying the properties of active particle motion with directional reversals. Some bacteria, like Myxococcus xanthus and Pseudomonas putida, exhibit a unique kind of direction reversing active motion, whereby, in addition to a diffusive change of direction, the motion also completely reverses its direction intermittently. How far does such microorganisms typically disperse in a given time? How long does it take (first-passage time) to find a food source? These questions are crucial in characterizing this kind of direction reversing motion. A simple model to describe such motion is a Direction Reversing Active Brownian Particle (DRABP). The interplay of the two time scales set by the rotational diffusion constant and the reversal rate is expected to lead to a complex dynamical behaviour as well as interesting phases in the stationary state in the presence of external potential. We are presently studying the DRABP model analytically with particular focus to the position distribution and first-passage time distribution.