**Bullets points:**

1. introduction （back gourd motivations)

1. Active particles are out of equilibrium (local consumption energy)

2. True non-equilibrium features (citation) arise from the interactions of active particles with 1) their environments 2) other particles(active or not)

**Examples**:

* Single ABPS or RTPs;

1) collective motion (Vicky, chati taillur)

2) MIPs (cates, tailleur andREdnes)

3) Active jaming (bertrand, Hunks ,Biand manning)

* Rods Polar and numerical order (Baskasam and Manchetti)

2. What about active polymers? Extended objects, semi-flexible (control bending rigidity)

3. Research projects:

A) Active polymers in complex environment

1) work done for regular arrays of obstacle. Consider more about more realistic environments (compliant/ flexible obstacles)

2) Optimal transport in complex environments (cargo/drug delivery system) Disorder obstacles ect….

B) Emergence of collective motion in suspensions of active polymers

c) Transport of mechanical statics microorganic swimmer in complex environments

d) Active wetting- surface/interface phase transitions in active matters.

**1. Introduction**

Active particles introduce fascinating phenomena in non-equilibrium systems due to their intrinsic energy consumption. These systems are characterized by the absence of detailed balance and the presence of continuous energy flux, leading to a plethora of dynamic behaviors not found in equilibrium (Marchetti et al., 2013). This complexity is further compounded when considering the interactions of these particles with their surroundings and with other active or passive particles. Examples of such systems include single Active Brownian Particles (ABPs) or Run-and-Tumble Particles (RTPs). Collective behaviors, such as flocking in models of self-propelled particles, have been extensively studied, revealing insights into the emergence of order from local rules (Vicsek & Zafeiris, 2012). In particular, the work of Hugues Chaté and Francesco Ginelli has been revealing insights into the emergence of order from local rules without cohesive interactions among self-propelled particles (Chaté & Ginelli, 2008). Additionally, phenomena like Motility-Induced Phase Separation (MIPs) illustrate how particle propulsion can lead to phase separation under non-equilibrium conditions, without the need for attractive forces (Cates & Tailleur, 2015; Redner et al., 2013). Anand, Lee, and Bertrand investigate the threshold behaviors in active matter systems, revealing the dynamics at the brink of jamming (Anand, Lee, & Bertrand, 2023). Additionally, M. Lisa Manning explores the role of active jamming in biological processes, particularly its impact on cellular movements and interactions in various contexts (Manning, 2015). Dapeng Bi further delves into the complex transitions in biological tissues under the influence of active jamming, offering a perspective on the interplay between motility and material properties in living systems (Bi, 2016). These studies collectively enhance our understanding of active jamming, bridging the gap between physical principles and biological phenomena. Research on active rods has provided a platform to understand how anisotropy in particle shape influences collective dynamics, leading to distinct polar and nematic orderings (Baskaran & Marchetti, 2009).

**2. The Design of Active Polymers**

Active polymers are a class of active materials composed of long, chain-like molecules that can undergo autonomous motion and exert forces on their surroundings. They are particularly interesting due to their extended structure and the ability to control their bending rigidity, making them a versatile system for studying non-equilibrium dynamics.

Extended Objects in Active Matter:

Extended objects, like active polymers, differ from point-like active particles in that their shape and conformation significantly influence their dynamics and interactions. The extended nature of these polymers allows for the study of phenomena like entanglement, alignment, and collective motion in a way that is not possible with point-like particles.

Semi-Flexibility and Bending Rigidity:

The mechanical properties of these polymers, particularly their bending rigidity, play a crucial role in determining their behaviour. Semi-flexible polymers can exhibit a range of dynamics from rigid-rod-like behaviour to flexible-chain-like behaviour, depending on the bending rigidity.

**3. Research Projects**

**A. Active Polymers in Complex Environments**

1. Prior studies have primarily focused on active polymers navigating through static, rigid obstacles (Bechinger et al., 2016). However, the natural environments these polymers might interact with are often more chaotic and feature obstacles that are not fixed in space and can deform upon interaction. By considering these dynamic elements, the research can mimic more accurately the biological and ecological systems in which active polymers are found (Kaiser et al., 2014).
2. The research will delve into how active polymers can be steered and how they can navigate through disordered environments efficiently. This is particularly relevant for biomedical applications where the polymers could be used to transport pharmaceutical agents to specific sites within the body, akin to targeted drug delivery systems (Sengupta et al., 2012).

**B. Collective Motion in Active Polymer Suspensions**

This project will investigate the microscopic interactions that lead to macroscopic order and movement in a many-body system of active polymers. It will also consider the role of hydrodynamic interactions and the influence of concentration and rigidity in the emergence of collective dynamics (Zhou et al., 2014).

**C. Transport of Mechanical Statistics in Micro-Organic Swimmers**

Investigating micro-organic swimmers' transport mechanisms in complex fluids will provide insights into non-equilibrium statistical mechanics. The research will focus on how these swimmers navigate through heterogeneous media, which is crucial for understanding biological processes such as sperm motility and bacterial locomotion (Lauga & Powers, 2009).

**D. Active Wetting and Surface/Interface Phase Transitions**

Active wetting phenomena represent a frontier in the study of non-equilibrium phase transitions. This project will explore how active particles interact with interfaces and how their collective dynamics lead to the wetting and dewetting of surfaces, providing insights into the non-equilibrium processes that drive these transitions (Joanny & Ramaswamy, 2012).

**Further Research Plans**

**A) Active Polymers in Complex Environments**

1. Read up on what's been done with active polymers and obstacles. Focus on the differences between simple and complex (like flexible) obstacles.
2. Design my own experiments. Think about how to make obstacles mimic real-life situations, like in drug delivery.
3. Run the stimulations. track how the polymers move around the obstacles.
4. Analyse the data. Are the polymers behaving like my thought they would? What's different when the obstacles change?
5. Write up the results. Aim for journals or conferences.

**B) Emergence of Collective Motion in Suspensions of Active Polymers**

1. Literature review on how active polymers move together. Form guesses about what might influence this.
2. Set polymer suspensions ready and set up ways to observe how they move as a group.
3. Watch how the polymers behave in the suspension. Record their movements and any patterns I observe.

**C) Transport of Mechanical Statics Microorganic Swimmer in Complex Environments**

1. Pick the right micro-swimmers for my study. Read about how they usually move in different settings.
2. Set up environments that are like where these swimmers would be found naturally. Think about different layouts and challenges they might face.
3. Look closely at the data and find pattern. How do the swimmers handle different challenges?

**D) Active Wetting: Surface/Interface Phase Transitions in Active Matters**

1. Read about active wetting and phase transitions. Develop my own ideas about how these processes work at the microscopic level.
2. Figure out how to test the ideas. This might involve setting up surfaces or interfaces and watching how active particles interact with them.
3. How the particles behave at different surfaces or during phase transitions.

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