Emergent Disorder Induced Transport in Active Matter Systems

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Main Purpose

- Create an application that randomizes posts as CAD files
- Print functional prototypes
- Use prototypes in specific field

Goals

Synthetically mimic the ubiquitous biological process known as chemotaxis.Using super paramagnetic mircrorobotic walkers that spontaneous self assemble and proceed to walk across the surface upon actuation of a rotating magnetic field. By coupling walkers to the surface using biological ligand-receptor pairs biotin-streptavidin, we were able to modulated walker velocity. By creating gradients in density of binding sites and placing the walkers on random walk paths, we were able to observe chemotactic motion, which has potential to impact fields in various medicine, sensors, microfluidics.

Active Matter Systems

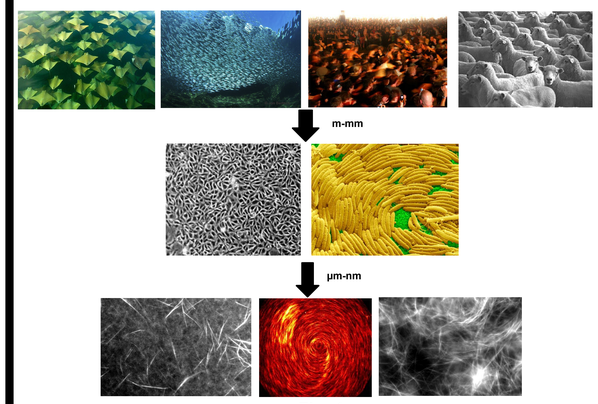


Fig. 1
Active matter systems spanning multiple length scales[1]

- **Active units/particles** continuously convert ambient, stored, or chemical energy ***locally*** into motion
- In dense systems the motion of active particles can lead to the appearance of **collective dynamical behavior and large scale flows**
- **Emergent interaction range** and **nature** depend on level of **activity**, **environment**, and **mode of activity**

Emergent Active Matter Interactions

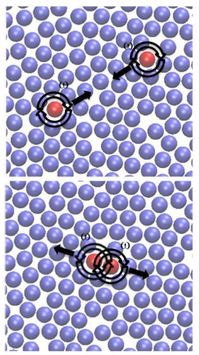


Fig. 2:
Force reversal when mode of activity is changed

- **Emergent long range interactions** found in **hybrid active-inactive systems** of activ spinning particles in a **dense monolayer** of passive particles
- Interaction is due to the **mechanical**, **elastic**, properties of the **passive monolayer** and the **activity** of the spinning particles.
- Simulations show **interaction can be reversed** if the spinners are **counter-rotating** instead of **co-rotating.**

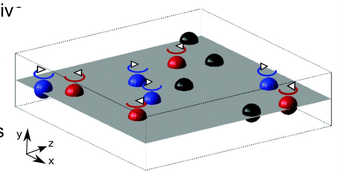


Fig. 3
Non-equilibrium steady state of co-rotating clusters (blue and red) and passive particles (black).

Magnetically Actuating the Rollers Utilizing A Helmholtz Coil Inspired Apparatus

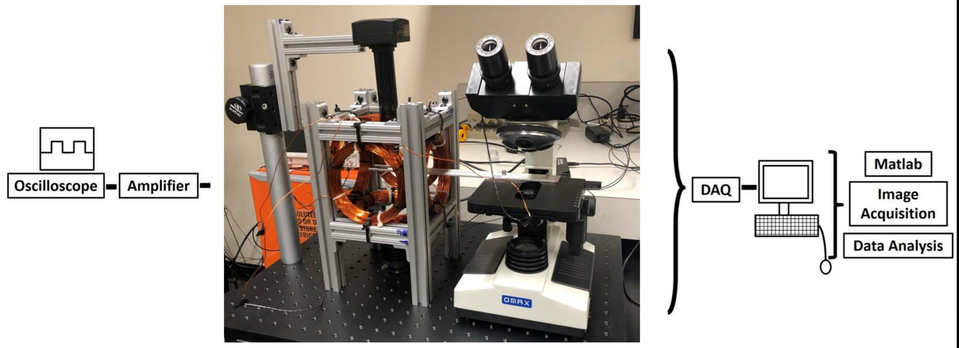
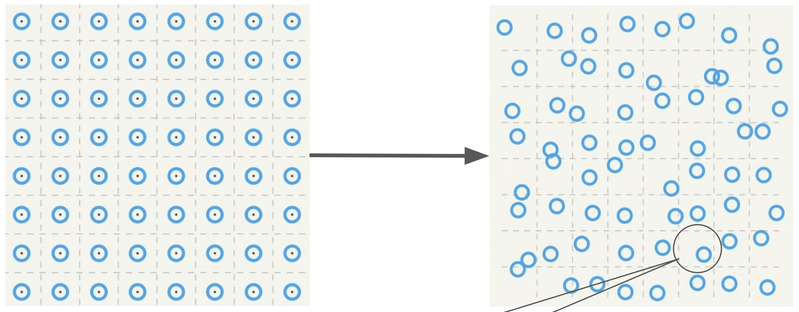


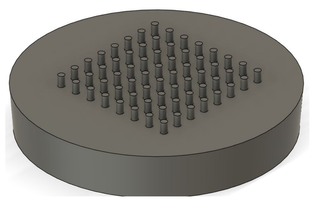
Fig. 5
Experimental apparatus consisting of six coils. Sample is placed at the center of the coils and the monolayer is sealed between the glass slide and cover slip using epoxy

- Send **sinusoidal currents** that are **phase shifted** in **order to create a rotating magnetic field** to drive **magnetic bead motion**
- **Helmholtz-Coil inspired apparatus** generates **uniform magnetic** field and **3D apparatus** is general and can drive **multiple modes of motion: rolling, spinning, tops, etc.**

3D Printing and Control of Post Locations



- **A grid of points is generated, initially we generated a grid of 8 by 8 points.**
- **A random offset vector is then applied to the initial point position of each point and a circle is drawn around the resulting point.**
- **The modified grid is exported as a DXF and brought to Fusion 360 to extrude the circles into poles to make physical obstacles**



Magnetic Particles in Post Environment

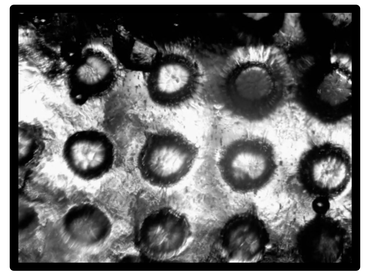


Fig. 6
Particles going up & down around pillars

Fig. 7
Particles spinning around pillars

Disorder Induced Transport

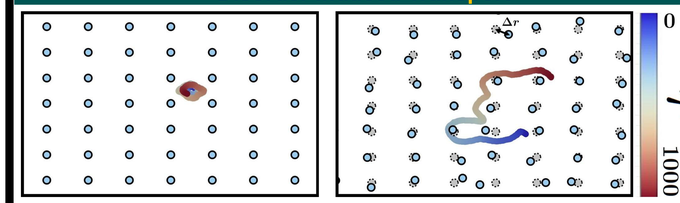


Fig. 4
Disorder in the lattice induces translation of particles

Limitations

- Evaporation of channels
- Walkers walking due to the actuation of field and the gradients as opposed to the induced flow of other walkers.

Conclusion

This application will be used to further extend Dr. Joshua Steimels research in how magnetic particles travel through varying magnetic fields in search of emerging patterns that could be applicable in the medical field; furthermore, we were able to create successful prints and a functional way to randomize posts within a radius in order to track motion through said magnetic fields.

Acknowledgements

- University of the Pacific
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- UOP Chemistry Department
- UNC Chapel Hill
- Kallian Wilson (Pillar Randomization Software)

Selected References

http://web.bf.uni-lj.si/bi/sprcenter/2-Senzorgram-completeENG.gif