TEACUP ROCKET EXPERIMENT

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OUTLINE

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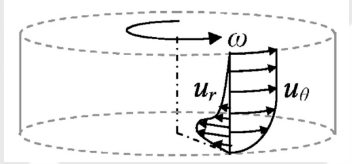
INTRODUCTION

- Objective
  - To investigate effectiveness of ‘electric tempest in a teacup’ method for microfluidic separation in microgravity
- Team
  - 5 SpaceMaster students at LTU, Kiruna: Mark Fittock, Samuel Webster, Martin Siegl, Fan Chunman, Pooja Mahapatra

INTRODUCTION

- Einstein’s tea leaves: circular stirring in a teacup
  - Friction at cup base
  - Reduction in centrifugal force towards cup bottom

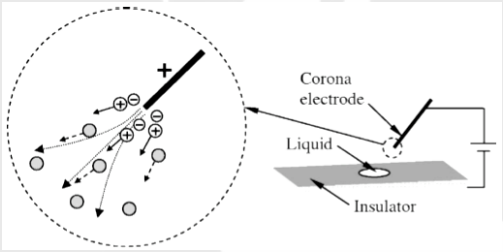


MOTIVATION

- Efficient separation difficult in microfluidic devices
- Some methods:
  - Strong centrifugation: difficult to achieve in nanoscale, cumbersome machinery
  - Microfabricated filters: complex membranes and fabrication techniques, deformation and denaturing of cells in case of blood
  - Dielectrophoresis (DEP): ineffective below 10μm particle diameter

PRINCIPLE

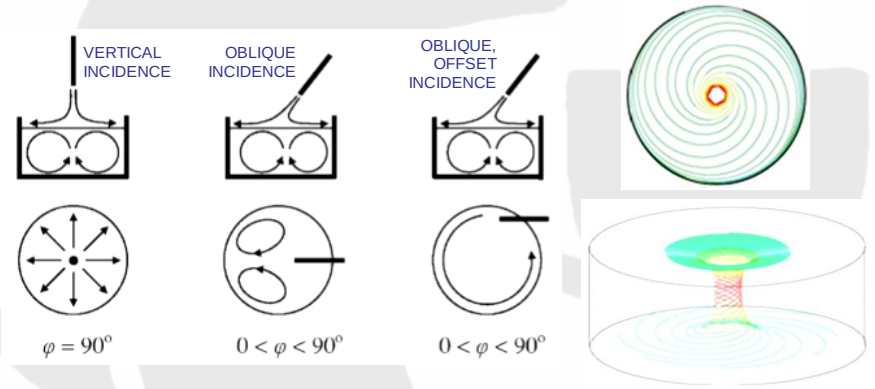
- Ionic wind
  - V > threshold air ionization voltage
  - Corona discharge around sharp electrode tip
  - Plasma counterions collide with electroneutral air molecules, transfer momentum



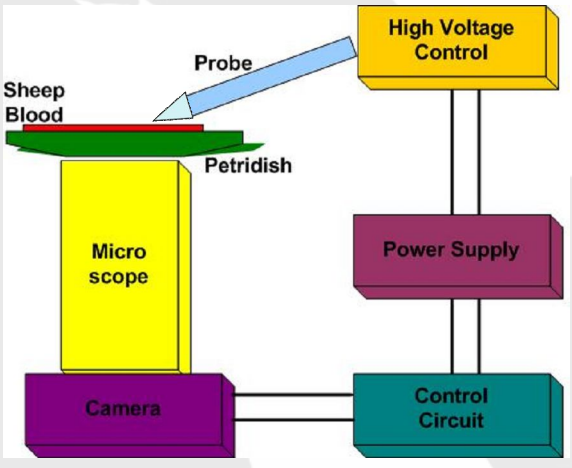
PRINCIPLE

- Orientation effects

  ø = angle between probe and fluid surface



SETUP



REQUIREMENTS

- Microfluidic chamber (8 mm diameter, 4 mm depth)
- Separation medium: Diluted sheep's blood (enables easy visualization)
- ~3 min microgravity time, 1 bar pressure and 23 ° C to be maintained in rocket chamber
- High voltage supply and sharp probe
- On-board image acquisition and data storage hardware

ADVANTAGES

- No mechanically moving parts
- Small sample size
- No electrode-sample contact: mechanical failure, sample contamination prevented
- Little field penetration into fluid: no adverse effects on biomolecules
- Minimal current, low power
- Particle aggregates undisturbed after removal of electric field
- Miniaturization possible: piggybacking for rocket launch

DRAWBACKS

- Risk due to high voltage: adequate safety precautions necessary while implementing and testing
- High cost
- Piggybacking, hence no data transfer back to ground: post-launch experiment recovery is crucial

APPLICATIONS

- Miniature, low-power replacement for centrifuge (for experiments in physics, biology, materials)
- Portable medical diagnostic kits for astronauts, especially in long-duration spaceflights
- Microarray chips in high-throughput drug screening

CONCLUSION

- Ion-jet induced vortex separation holds promise for miniature implementation on board spacecraft
- The project is currently in the design phase
- Launch options are being explored
- After implementation, rigorous ground testing is important to validate results of microgravity experiment

REFERENCES

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THANK YOU