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Creation and Application of Nanobubbles

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Motivation

Nanobubbles (NBs) are tiny gaseous domains within an aqueous solution, that are between 50 and 500 nm in radius. They can be generated through various methods including hydrodynamic cavitation, solvent exchange, temperature change, turbulent flow, electrolysis, chemical reactions, and ultrasonic. They are unique, regarding their longer lifetimes, surface charge and gas/liquid/solid interface contact angle improvement. Their unique properties make them promising for water treatment, mineral processing, cancer treatment, and energy storage [1-4].

However, the fundamental influence of external forces such as magnetic fields on nanobubble stability remains poorly understood. Achieving control over their behavior through magnetic interactions could unlock new opportunities in environmental and biomedical engineering (Fig. 1).

Technological challenge

The most unique characteristic of bulk NBs is their remarkable longevity. While microbubbles (MBs) have a lifespan of seconds, NBs have been observed to exist for weeks or months. Nanobubble interfaces in pure water have been shown to be negatively charged, indicating the development of an electric double layer around the NBs. The accumulated ions surrounding the bubble surface form a thin layer that functions as a diffusion barrier, decreasing gas dissolution and therefore prolonging the NBs lifespan [5].

Since the electric double layer plays a central role in nanobubble stability, our research investigates how rotating magnetic fields with alternatively oriented configuration (Fig. 2), which can induce electric fields, may be applied to further enhance or control this effect.

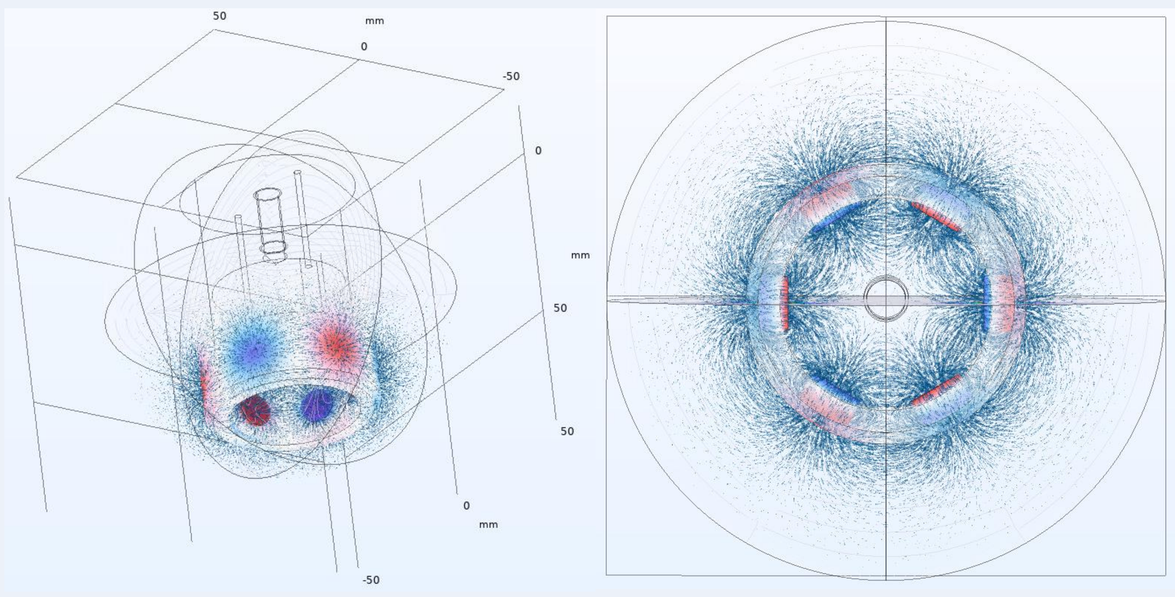

Fig. 2. Schematic of a rotating magnetic field with alternatively oriented north–south (N–S) configuration for nano bubble stabilisation

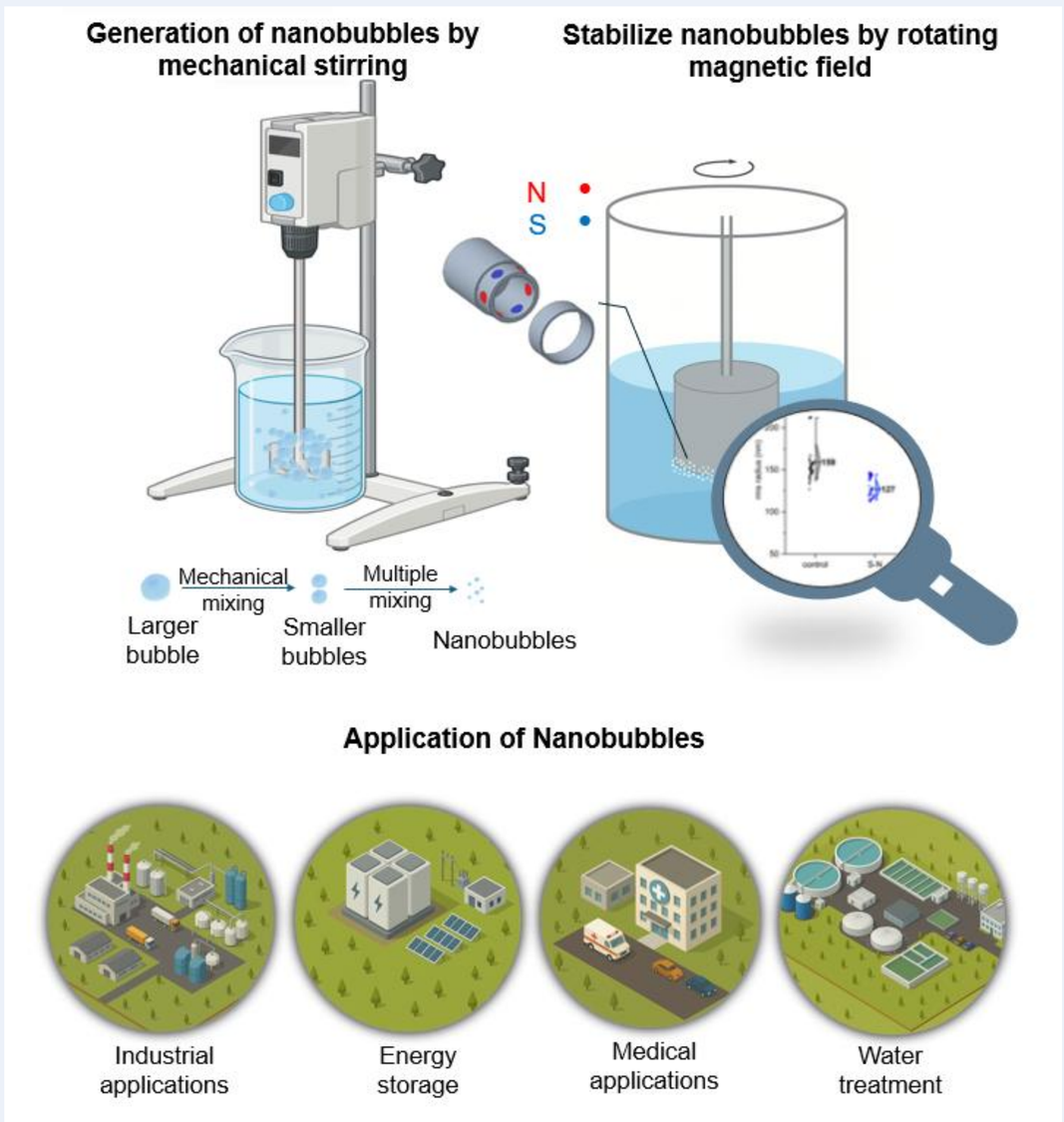

Fig. 1: Creation of nanobubbles by mechanical stirring and stabilisation by magnetic fields (upper part); possible applications (lower part)

Research goals

- Develop reliable, reproducible and robust methods for nanobubble generation
- Investigate how magnetic fields affect stability and charge distribution of nano bubbles
- Combine experiments and modeling to understand the mechanisms of external magnetic field interactions
- Create a theoretical framework for controlled nanobubble behavior.
- Explore water treatment related applications of magnetically stabilized nanobubbles.

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[5] A.W. Foudas et *al. Chemical Engineering Research and Design* **189** (2023) 64-86