

# Magnetic Viruses : A Novel Concept for Biological Sensors

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## Motivation

Biology + Magnetism



**BioMagnetics : an emerging field of biophysics**

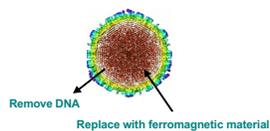
- Biological affinity is used for recognition function
- Magnetic nanoparticle : label for biological substance
- Magnetic interaction allows easy manipulation and detection

**New detection scheme for biological systems**

## Magnetic Virus

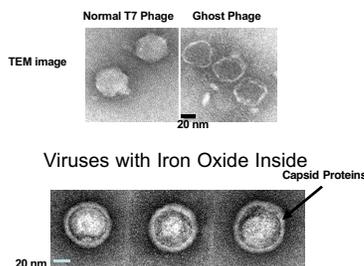
**What is a Magnetic Virus ?**

T7 bacteriophage virus with magnetic nanoparticles inside

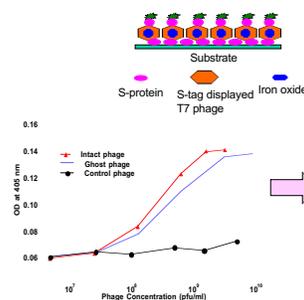


- Ligand-displayed phage viruses has recognition function for target molecules
- "Ghost phage" without DNA core is prepared by osmotic shock (uniform cavity size ~30nm)
- Ghost phage viruses are utilized as a template for magnetic nanoparticles

**Fabrication of Phage-templated Magnetic Nanoparticle**



**Binding Activity of Magnetic Virus with S-protein**

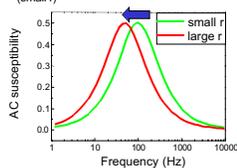
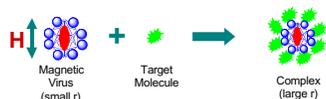


Ghost phage still has recognition function!!

## Sensor Schematics

**Biosensing through changes of dynamic magnetic properties**

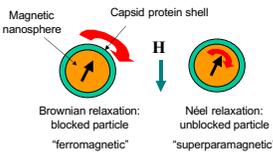
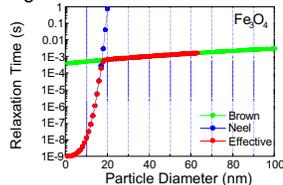
Frequency shift in AC susceptibility due to change of hydrodynamic radius



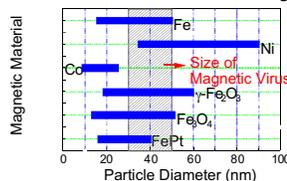
$$\chi'(\omega) = \frac{\chi_0 \omega \tau}{1 + (\omega \tau)^2} \quad \text{where relaxation time } \tau_H = \frac{4\pi \eta r^3}{k_B T}$$

**Physical Properties of Magnetic Virus**

Magnetic Moment Relaxation in Fluid



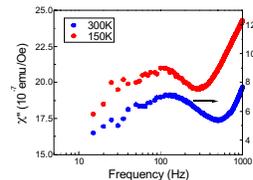
Particle Diameter for Stable Single Domain



Magnetic virus is ideal !!  
(Single domain with Brownian relaxation)

**Preliminary Results**

Sample: 350 nm Streptavidin Coated  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>



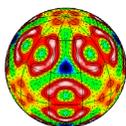
- Peak remains even below the freezing temperature of suspension liquid: Not Brownian relaxation
- Maybe due to multidomain/curling structure or aggregation of large particles

## Conclusion

- Fabrication of magnetic virus  
New hybrid materials with recognition functionality
- Developed new magnetic sensor scheme  
New type of small and portable biosensor

## Outlook

- Development of working bacteriophage based biomagnetic sensor
- Other applications of magnetic viruses such as target drug delivery and MRI
- Pathways to single molecule detection



BES - DOE

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