# Visualization of electromagnetic characteristics in superconductors

Chunbo Liu　　Baorong Ni

Graduate School of Engineering, Fukuoka Institute of Technology

## 1. Introduction

In the application of superconductors, it is necessary to correctly understand electromagnetic characteristics such as critical current density and AC loss. However, these electromagnetic characteristics are difficult to express visually and may be difficult to understand. Therefore, in this research, the critical state model and its development model were used to quantitatively describe various physical quantities and a software called Processing were used to visualize them.

## 2. Research method

The purpose of this study is to realize the spatial distribution of magnetic flux density, critical current density and AC loss under the assumption that there is an alternating magnetic field parallel to the superconductor.

Processing language is based on the Java language, which can easily convert data into graphics. This research uses it to express the changes in the electromagnetic properties of the superconductor cross section.

Supposing the AC magnetic field is parallel to the superconductor. Assuming that the length of the superconductor is sufficient longer than the width and height, only the variations of electromagnetic properties in the cross section of the superconductor need to be analyzed. Then the model like Figure 1 can be established.

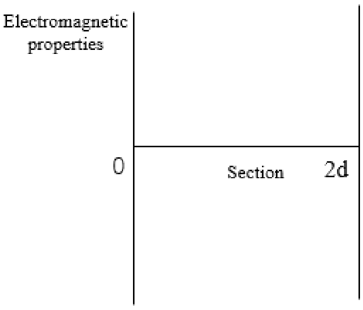


Fig.1 Cross section of superconductor

For the AC loss density p, this study uses the depth of the RGB image to indicate the size of the AC loss.

When a magnetic field is applied to the superconductor, the magnetic flux lines enter the superconductor in a quantized form, and the magnetic flux density distribution follows the critical state model. The critical state model satisfies Maxwell's equation.

We bring the Bean model 1 into discussion

$$J = \alpha_c (fixed\ value) \quad (1)$$

The electromagnetic characteristic distribution inside the superconductor section is obtained based on Bean model[1].

$$\delta B = \delta_0 B_0 - u_0 \alpha_c x \quad (2)$$

$$p = \frac{\partial H_0}{\partial t}(\delta B - \delta_b B_b) \quad (3)$$

$B, p, J, \delta, B_b$ respectively are magnetic flux density ,AC loss, current density, the direction of the magnetic flux density and the transition of the magnetic field.

## 3. Results and discussion

First supposing that the external magnetic field varies sinusoidally. Divided the change process into five phases according to the direction of the external magnetic field and the peak magnetic field.

This research was simulated with Processing and a simulation diagram like Figure 2 can be obtained.

As shown in Figure 2, the upper left corner is the distribution of the magnetic flux density on the cross section, the lower left corner is the distribution of the critical current density on the cross section, the upper right corner is the distribution of the AC loss density, and the lower right corner is the RGB image in color Reflect the size of the AC loss density[2].

From the simulation, when the external magnetic field changes, the internal magnetic flux density, current density, and AC loss density of the cross section can be clearly seen.

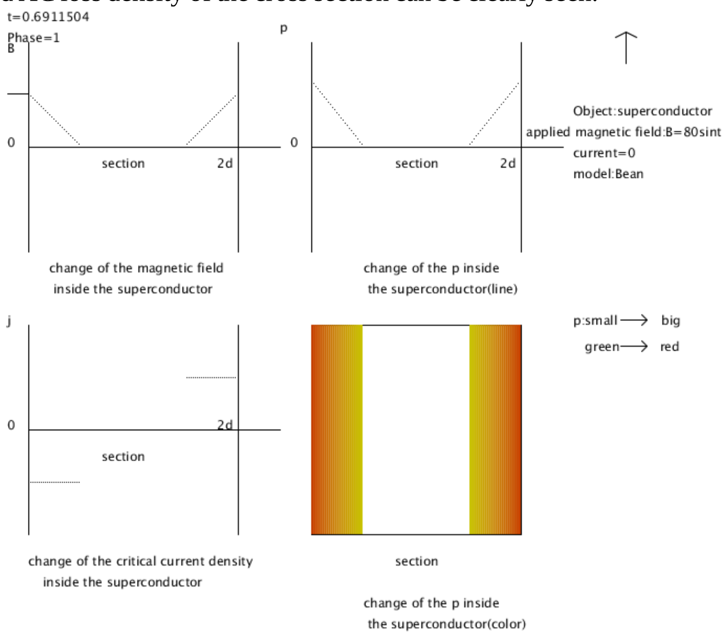


Fig.2　Simulation diagram

In many cases, the Bean model is not satisfied with the experimental results . Improved models such as kim model and the Irie-Yamafuji model are more consistent with the actual situation.

## 4. Conclusion

Using Processing, and with the help of the critical state model, the spatial distribution of magnetic flux density, critical current density and AC loss can be easily obtained and visually easier to understand.

REFERENCES

[1] 仁田旦三., ”超電導エネルギー工学”,pp.32-40,2006.

[2] Casey Reas. ”Getting stared with Processing”pp.32-36.2011.