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A PROPER PROBABILITY FUNCTION FOR N-AXIAL EASY AXIS DISTRIBUTION

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1. INTRODUCTION

Information about magnetic easy axis distribution is very important to understand magnetic properties of permanent magnet [1] as well as thin-film recording media [2]. Many authors have been reported magnetic analysis techniques based on the probability function of Gaussian (G) and Lorentzian (L) to describe the easy axis distribution of partially aligned system. However, G and L are not proper probability function because they do not show the uniaxial symmetry of $f(\phi+\pi)=f(\phi)$. In addition, they are not applicable to a sample having widely distributed easy axes because they don't satisfy the condition of $\int_{-\pi/2}^{\pi/2} f(\phi)d\phi = 1$. In this paper, we report a new probability function for the magnetic easy axis distribution and it's advantages over G and L.

2. THEORY AND DISCUSSIONS

Let's consider conditions that a probability function of the easy axis orientation should obey. The function should satisfy a n-axial symmetry of $f(\phi+\pi/n-\phi_C,d)=f(\phi-\phi_C,d)$, a sum rule of $\int_{\phi_C-\pi/2n}^{\phi_C+\pi/2n} f(\phi-\phi_C,d)d\phi = 1$, and a relation of $f(\phi-\phi_C,d)\geq 0$. Here, ϕ_C and ϕ are angles of the maximum probable orientation and the easy axis orientation, respectively. d is the half width at half maximum (HWHM) of the probability function. One can find a function expressed by Eq. (1) satisfies all conditions mentioned above.

$$f(\phi-\phi_C,d)=\frac{n}{\pi}\frac{\tan(nd)(1+\tan(nd))}{\tan^2(n(\phi-\phi_C))+\tan^2(nd)} \quad . \tag{1}$$

Eq. (1) satisfies $f(\phi-\phi_C=\pi/2, d\neq\pi/2n)=0$ and $f(\phi-\phi_C, d=\pi/2n)=n/\pi$. It should be noted that the HWHM (d) of $\pi/2n$ means uniform distribution of easy axis for the n-axial symmetry case. Fig. 1 shows typical examples of evaluating $f(\phi-\phi_C,d)$. Direct comparison was carried out by fitting G and L to the data obtained by evaluating present function, as seen in Fig. 2. Present function with a small HWHM shows L behavior. Definite integral, $I(d)$ defined by $I(d,n)=\int_{\phi_C-\pi/2n}^{\phi_C+\pi/2n} f(\phi-\phi_C,d)d\phi$, is evaluated with $n=1$ to test the sum rule. The definite integral of our function gives exact 1 as seen in Fig. 3. Rigorously speaking, if the definite integral of a function deviates from 1, the function can not be used as a probability function. Fortunately, the definite integral of G shows negligibly small deviation from 1 when HWHM is smaller than 30 deg. Hence, previous works based on G with a smaller HWHM than 30 deg. are valid. However, the constraints in using G and L as a probability function will be severe for the biaxial case.

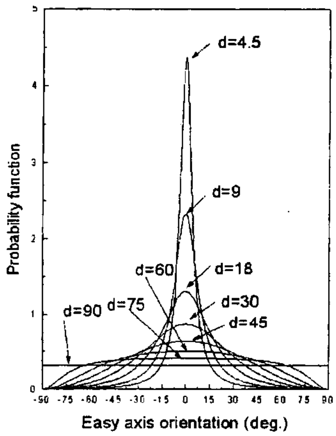

Fig.1 New probability function.

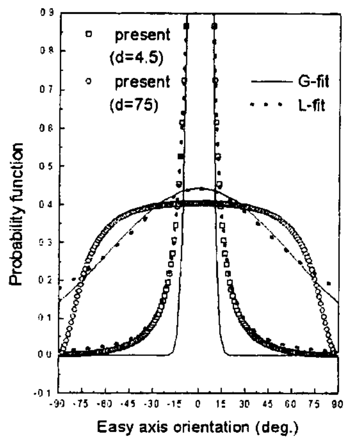

Fig.2 Comparisons by fitting.

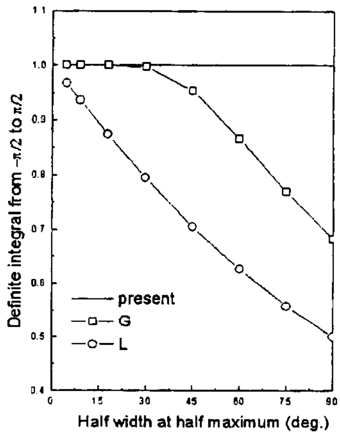

Fig.3 Sum rule test.

3. CONCLUSIONS

We present a new probability function for n-axial easy axis distribution and discuss it's properties. Our probability function is mathematically correct and practically accurate. Furthermore, it can be used to accurately describe high-n-axis angular symmetry. This is a unique and remarkable advantage over G and L

REFERENCES

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