遮蔽的磁极

——由一个电磁学实验现象展开的讨论

姓名：郭一昕
学号：PB15121740
指导老师：林渲滨

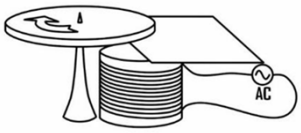
Sir. John. Ambrose. Fleming

1877年进入剑桥大学卡文迪许实验室
在麦克斯韦指导下研究电学和高等数学

英国物理学家、工程师
伦敦大学和皇家化学院获理学士
诺丁汉大学学院物理学和数学教授

现象介绍

把一个非铁磁性的金属圆盘放在有交流电驱动的电磁铁上，金属盘会排斥但不会旋转，然而如果把一个非铁磁性的金属片放在圆盘和电磁铁之间的话，金属圆盘就会开始旋转。



WEEKLY EVENING MEETING,

Friday, March 6, 1891.

WILLIAM CROOKES, Esq. F.R.S. Vice-President, in the Chair.

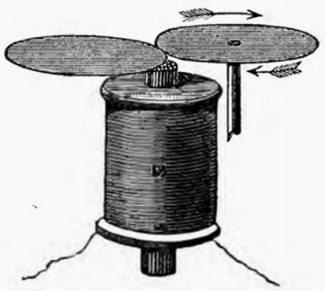
PROFESSOR J. A. FLEMING, M.A. D.Sc. *M.R.I.*

Electro-magnetic Repulsion.

§ 1. ON the 2nd day of October, 1820, Ampère presented to the Royal Academy of Sciences in Paris an important memoir, in which he summed up the results of his own and Arago's previous investigations in the new science of electro-magnetism, and crowned that labour by the announcement of his great discovery of the dynamical action between conductors conveying electric currents.* Respecting that achievement, when developed in its experimental and mathematical completeness, no less a writer than Clerk Maxwell calls it "one of the most brilliant in the history of physical science." Our wonder at what was then accomplished is increased when we remember that

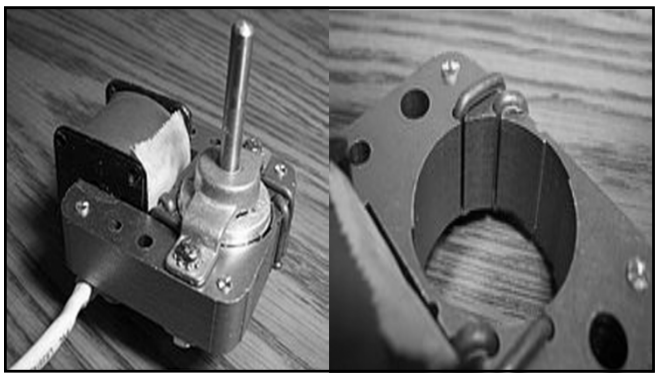
and in the movable one. The fixed disc shields part of the other from the induction of the pole, and hence causes the induced currents in that plate and disc to be so located that they are in positions to cause continual attraction between one another and continuously pull round the movable disc into fresh positions, so creating regular rotation. This principle of "shading" a pole is employed in constructing the polar coils of the magnet used in our experiment a moment ago, and the experiments present us with

FIG. 11.

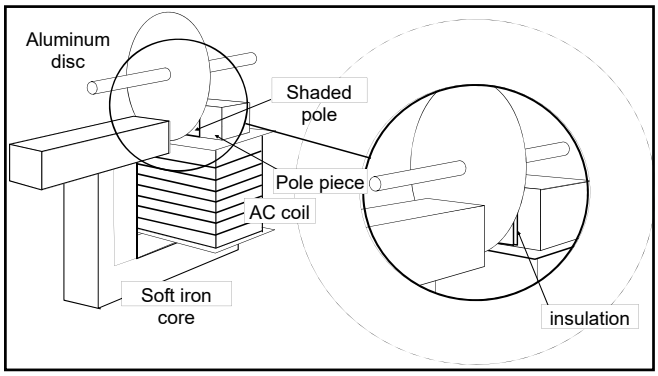


Revolution of a shaded copper plate held over an alternate-current magnetic pole.

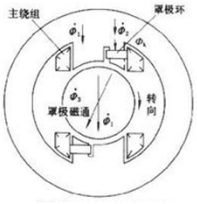
由此
一场电动机历史上
重要的革命
悄然开始



罩极式电动机(Shaded Pole Motor)



罩极异步式电动机的原理



通电以后，主绕组会产生两部分磁通量，
一部分为不穿过罩极绕组的磁通量Φ_1，
另一部分为穿过罩极绕组的磁通量Φ_2。
与此同时，Φ_2在罩极绕组中由于电磁感应原理要产生感应电动势E_k，由于有闭合回路的存在则有电流I_k的产生。
而产生的感应电流I_k也会产生磁通量Φ_k，
那么罩极中的总磁通量Φ_3应该为Φ_2和Φ_k之和。
但是Φ_3在时间上要落后于Φ_1，
由于非罩极部分的磁通Φ_1与罩极部分的磁通Φ_3在空间及时间上均有一定的相位差，
产生椭圆形旋转磁场，从非罩极部分向罩极部分转动。
如此一来，通过电磁感应在转子绕组中感应起电流，
产生起动转矩，使转子转动。

$\nabla \times \mathrm{H} = \mathrm{J} + \frac{\partial D}{\partial t}$ 全电流定律的微分形式

$\nabla \times \mathrm{E} = -\frac{\partial B}{\partial t}$ 法拉第电磁感应定律的微分形式

显示了电磁场时空上的统一

罩极式电动机的应用?

生产生活中的方方面面

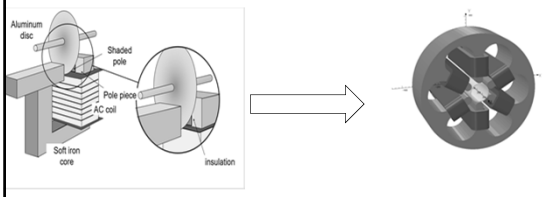
四驱车的电动马达

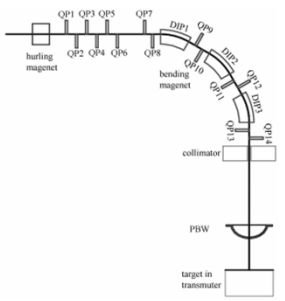
延伸讨论

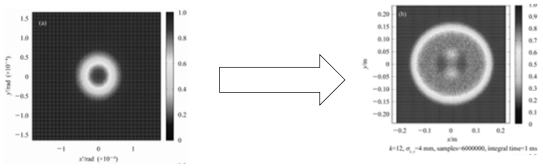
钱伟长发明穿甲弹的故事

Design of proton beam optics to realize beam distribution transformation in C-ADS HTBT

超导磁体的应用







相关参数

T_1：调幅周期

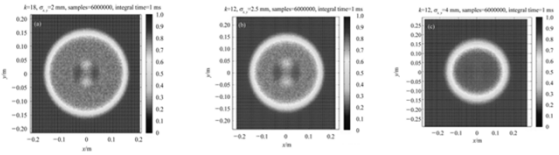
T_0：旋转周期

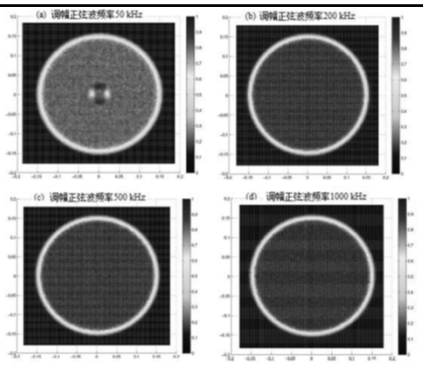
比例系数$k = \frac{T_1}{T_0}$

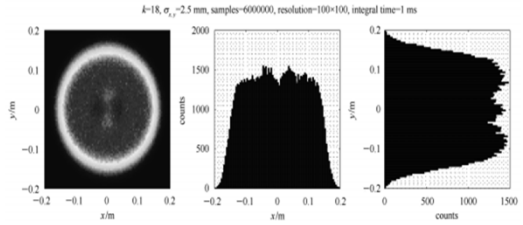
E：束流能量

samples：样本数

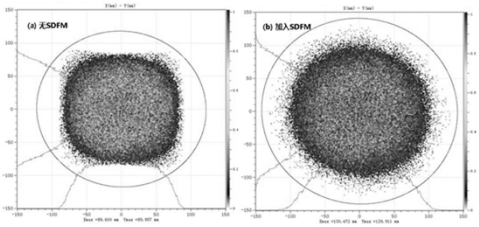
不同参数下所产生的束流耀斑





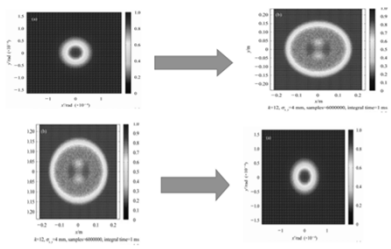


静态磁场情况

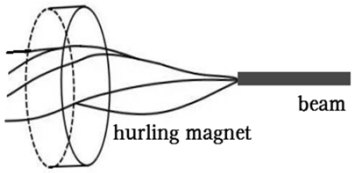


反对称简易六极场磁铁均束过程中，有无 SDFM 前后的束团实空间分布比较

High Intensity Electron and Positron Accelerator



High Intensity Electron and Positron Accelerator



感想一

我们在平常的科研与学习中，
不应该执迷沉溺于复杂的数理运算与推导，
而应该对生活中的各种小现象抱有好奇心。
去实践我们所学到的知识，
科学发展的最终要义在于
促进人类生活水平的提高。

感想二

我们应该留意每一次科研实验中的
任何一个微小的实验现象
乃至日常生活中
任何一个微小的细节
此后我们或许将有改变世界的创造

致谢

中国科学技术大学国家同步辐射实验室的研究员
王相綦老师为本次论文提供大量配图与制图协助，
在此特别表示感谢。

参考文献

【1】.J. A. Fleming. On electromagnetic repulsion. Proc. Royal Inst. of Great Britain (March 1891), pp. 72-92
【2】. Journ. Soc. of Arts (May 14, 1890),pp. 296-316
【3】. Jearl Walker. 6.22: Turning in the shade of a magnetic field. In: The Flying Circus of Physics with Answers (John Wiley & Sons, 1975),
【4】. Wikipedia: Shaded-pole motor,
【5】. Keith Gibbs. (v) The shaded pole motor (schoolphysics, 2013)
【6】. Design of proton beam optics to realize beam distribution transformation in C-ADS HTBT(2013)

Thanks
for
your patient and careful listening