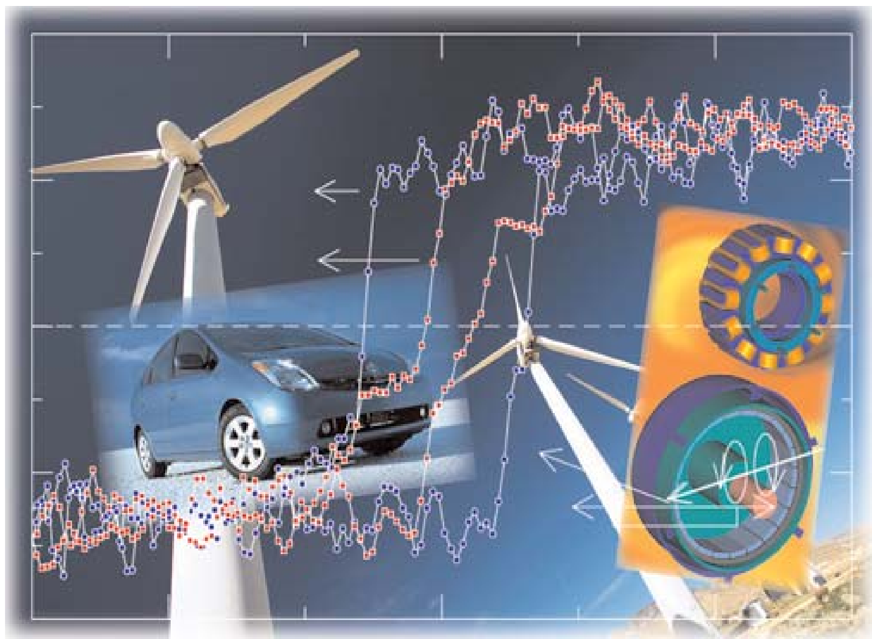
RARE INSIGHTS ABOUT PERMANENT MAGNETS

Permanent magnetic materials play a major role in the conversion of mechanical-to-electrical energy in alternators and generators and are used in a myriad of other products and technologies. Enhancing the performance of permanent magnets is bound to impact efforts in many areas, including energy conservation, miniaturization of electronic devices, and improving the magnet technology that is used to generate synchrotron radiation at light sources such as the Advanced Photon Source (APS) at Argonne National Laboratory. Researchers using the X-ray Operations and Research beamline 4-ID-D at the APS have found important new clues into ways to make those magnets longer-lasting and more powerful.



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Using the Western Hemisphere's most powerful x-rays at the APS, the researchers were able to see new details of rare-earth ions, a critical component of permanent magnets. This knowledge will enable manufacturers to manipulate the rare-earth ion atomic structure for optimization of future magnets.

Modern permanent magnets—chief amongst them neodymium-iron-boron—exhibit a large and persistent magnetization after a magnetizing field is removed. This is largely due to the presence of rare-earth ions in their structure (Neodynium), which add magnetic stability by way of the interaction between their anisotropic atomic orbitals and surrounding charges on neighboring atoms. This in turn determines a preferred orientation of the magnetic moments relative to the material's crystalline axes, effectively pinning the magnetic moments. Rare-earth ions come from metallic elements that share similar properties; they are not, in fact, especially rare, but they are used sparingly because of the high cost of preparing the materials. Rare-earth ions play an important role in determining magnetic stability against demagnetizing fields, and therefore in magnet performance.

In a unique set of experiments merging diffraction and spectroscopic techniques and using the circularly polarized x-ray beams from beamline 4-ID-D, the researchers succeeded in separating the magnetic contributions of two types of rare-earth neodymium ions in dissimilar atomic environments. This separation, not possible with other techniques, led to the discovery that only one of the two types of neodymium ions enhances the magnetic stability of the best-performing magnet to date. The other type, surprisingly, reduces the magnetic stability, providing important new clues into how to manipulate the local atomic structure for future optimization of permanent magnets.

See: D. Haskel, J. C. Lang, Z. Islam, A. Cady, G. Srajer, M. van Veenendaal, P. C. Canfield, Phys. Rev. Lett. **95**(21), 217207 (2005).

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