Cheaper Color Printing by Harnessing Ben Franklin's Electrostatic Forces

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Recent advances in the basic science of electrostatics could soon lead to color laser printers that are cheaper and up to 70 percent smaller than current models, a physicist reports at this week's AVS International Symposium and Exhibition in San Francisco.

Speaking at an AVS session commemorating Benjamin Franklin's 300th birthday, Schein will explain how Franklin's pioneering studies on electrostatics
have laid the foundations for the technology used in photocopiers and laser printers. Surprisingly, while these effects are well known, some of them remain among the most poorly understood areas of solid-state physics.

Even small children are familiar with the fact that charged objects can stick to each other -- probably the oldest known electromagnetic phenomenon. Electrostatic adhesion is used in photocopiers, laser printers, and fax machines to make toner particles temporarily stick to surfaces such as paper before they are permanently melted onto the sheet by heat.

However, the detailed physics of electrostatic adhesion is still poorly understood. In particular, the forces that make the plastic-based toner particles stick to surfaces during the printing process are surprisingly strong. Experimental measurements have shown these forces to be at least ten times stronger than what one would expect from the formulas first-year physics students learn from textbooks.

Electrostatic attraction between two bodies is usually calculated by using the so-called Gauss' law, said physicist Lawrence Schein, a former Xerox and IBM researcher. But its use assumes that the distance between the two bodies is large compared to the distances between the charges. In practice, however, the size of the contact areas can become very small, resulting in very strong attractive forces.

In recent research papers, Schein and Stanley Czarnecki, of Torrey Pines Research, have shown how to correctly use Gauss' formula to explain the much stronger forces that had been measured experimentally. "The enhanced adhesion is due to the discreteness of the charges, some of which may lie very close to the contact point, where the electrostatic forces are strongest," Schein said.

Schein's insights have inspired the formation of Aetas Systems Inc., a technology start-up dedicated to developing new color laser-printing technology. Current color laser printers are more expensive and up to three times as large as black-and-white models. Working as a consultant for Aetas, Schein realized that reducing the strength of toner adhesion could lead to greatly simplified and cheaper color laser printers.

To reduce toner adhesion, Schein used a nanotechnology fix: he completely coated the toner particles with tiny silica balls -- as small as 10 nanometer wide, or a thousand times smaller than the toner particles themselves. The silica nanoballs keep the rough edges of the toner particle from coming into contact with a surface and minimizes the number of contact points. This minimizes the adhesion.

Laser printers use four kinds of toners -- black, cyan, magenta, and yellow -- to create four toner images before transferring them onto paper. Lower-adhesion toner makes it possible to build each color image onto a single belt without disturbing the other colors in the process. In current models, this problem is solved by using an additional belt to

accumulate the color toner images one color at a time, but this adds weight, complexity, and cost. "I have a so-called desktop color laser printer," Schein said, "but it's so bulky I had to buy a special desk for it."

Instead, based on Schein's ideas Aetas is developing the design of a new generation of single-belt laser printers, whose complexity and weight will be comparable to those of black-and-white models.

Citation: Wang et al., *Journal of Imaging Science and Technology*, July/August 2006, and
Czarnecki and Schein, *Journal of Electrostatics*, June 2004
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