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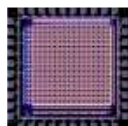
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X-ray future: low noise and colour

[15 december 2010]

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Imagine quiet X-rays for imaging

X-rays are incredibly useful in diagnostic imaging but also come at a price because they are ionising and so have potential to damage tissues. In work that combines informatics, quantum mechanics, and X-rays, researchers have found a way to cut the noise and so obtain far better X-ray images without increasing radiation dose.

Benoit Dupont established a start-up company in Antwerp, Belgium, back in 2006 called **Caeleste** with semiconductor scientists and circuit designers, A. Defernez, B. Dierickx (also at Vrije Universiteit Brussel) and N. Ahmed (University Pierre and Marie Curie, in Paris, France). The company is very active in the field of medical imaging and has now made, what Dupont describes as a "a major breakthrough": photon-counting in CMOS imager with energy sorting." The discovery could revolutionise X-ray imaging for medical and other applications and might also be applicable to spectroscopic techniques used by astronomers.

Counting photons

"The idea behind our breakthrough comes from the fact that ultimately while X-rays are a fantastic diagnostic method, they come at a price: the dose received by the patient, starts to be of concern for instance in mammography when people want to make a diagnosis every 2 years, or even every year." Dupont points out that to obtain an adequate image requires a relatively high dose because at lower X-ray dose, noise distorts the image too much making diagnosis impossible. Dupont explains that in very low light conditions, the readout noise of any instrument of device will impose a minimum number of photons required to reach a detectable level. "So, let's count photons. It will not solve the Poisson distribution of noise at high flux, but at least, we will be able to get rid of the device noise, because, no signal= 0 photon = 0 count, whereas 1 photon = 1 count." In this sense, X-ray imaging would thus be quantum limited, that is physically the lowest noise level you can ever get from a light source. However, if one is counting photons it should also be possible to determine their energy.

Colour comes to X-rays

Such energy measurements would be very useful to radiographers, explains Dupont, because they could then characterise the nature of the tissue being observed and reveal whether it is carbon rich, oxygen rich or a calcium-rich region. Such a distinction would allow X-ray imaging to differentiate bone (calcium), breast tissue (calcifications in tumours), blood (oxygen), muscle



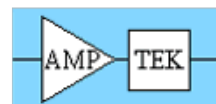
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(carbon and oxygen), water (oxygen) and fat (mostly carbon). In essence, X-ray absorption in matter has a strong spectroscopic dependence and so imaging could become a spectroscopic technique. Security X-ray systems have for several used years very high dose X-rays to distinguish different materials based on elemental composition and to produce false-colour images of the inside of a suitcase. However, the dose required is way beyond the safety threshold for medical applications.

The technique offers a surprise that would have startled Roentgen and his contemporaries: colour X-ray imaging. The Caeleste researchers are working with the university hospital of Brussels (UZB) to determine whether colour X-rays offer a significant clinical advantage over monochrome X-rays. Trials so far suggest that to be so. They have now run double blind tests with diagnosticians on colour and monochrome X-ray images and observed a more accurate prediction rate for multifocal tumours in the colour X-rays as well as an improved estimation of the actual size in a third of all cases. Dupont is convinced that the low-noise work and the development from the material-discrimination aspect of the research will lead to colour X-ray diagnosis being widely adopted in the future.

Details of this work will be published next year, although Caeleste revealed more details of the work on photon counting at the Optical Society of America symposium this year.

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