Lasers to give early-warning of volcanic eruptions

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Laser-based instruments could soon become a convenient tool to warn scientists of impending volcanic eruptions according to research reported today on the Institute of Physics website Optics.org. Researchers in Italy have built an optical system for monitoring volcanic gases and have just reported the results of their first field tests. Livio Gianfrani and his colleagues from the Seconda Universita di Napoli constructed a portable spectrometer based around a 2 micron diode laser and used it to perform in-situ measurements of carbon dioxide gas emissions from the nearby Solfatara crater.

"Analysis of the ratio of 13CO 2 to 12CO 2 is of the utmost importance in geochemical monitoring of active volcanic areas," research leader Livio Gianfrani told Optics.org. "A small change in the ratio, on the order of one part per million, can be due to magma movements towards the surface."

Currently, the isotope ratios of volcanic gases are measured by collecting gas samples and sending them to a laboratory for mass spectrometry measurements. Although highly sensitive and reliable, this process means that the results are typically available a few weeks later or longer.

"On the other hand, diode laser spectroscopy is ideally suited to make accurate, in-situ measurements," said Gianfrani. "If simple absorption detection schemes are adopted, such as wavelength modulation spectroscopy, it is possible to implement portable and reliable systems capable of continuous and unattended operation over time periods from

days to weeks."

The Naples team performed the gas measurements between July and October 2004 and report an accuracy of better than 0.05% in their ratio results. Their set-up is built on a 60x60 cm breadboard and consists of a room-temperature operated DFB laser diode emitting 3mW at 2.008 microns, a pair of gas cells (the sample and a reference), and a InGaAs photodiode detector. The equipment is controlled by a laptop computer and housed in a protective box that is thermally insulating.

According to Gianfrani one of the big challenges was making a system that was robust enough to stand up to the harsh conditions encountered at the crater.

“A volcanic site can be one of the worst environments on our planet," said Gianfrani. "Instrumentation can be exposed to acid gases, large temperature fluctuations and high humidity." For example, at the Bocca Grande vent on Solfatara the temperature of gases can reach 150 degC and gases such as hydrogen sulphide (H 2S) and methane (CH 4) are present in addition to CO2 and water vapor.

The gases are collected by a flask or a 20m long Teflon tube that directly feeds into the spectrometer sample chamber. A laser then scans the sample 30 times to probe the gas for its 13CO 2 and 12CO 2 absorption lines. A set of 10 measurements takes about 50 minutes."

The team is now thinking of ways to improve its set-up. "We are implementing a new version of the spectrometer based on a new diode laser in conjunction with a long optical absorption path length technique. This will increase the detection sensitivity," said Gianfrani. "We plan to perform isotope ratio measurements in atmospheric CO 2 at molecular densities much lower than those observed in volcanic gases, without any kind of sample treatment.

Source: www.optics.org