Final Technical Report for the Project

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entitled

UTILIZING LASER SPECTROSCOPY OF NOBLE GAS TRACERS
FOR MAPPING OIL AND GAS DEPOSITS

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Our research results have demonstrated that extending collinear fast beam laser spectroscopy to resonance-excitation field-ionization spectroscopy yielded a novel ultrasensitive method to identify minute amounts of radioactive and stable isotopes. The method is widely applicable and can be used with most atoms and isotopes. The main requirement is that it has resonance lines or other strong optical transitions in the UV and visible optical range. The method is therefore limited only by the availability of suitable lasers to be used as excitation sources. The achieved sensitivity for detection is in the few 100 atoms/sec region and also applies to cases where the relative abundance of the isotope of interest is extremely small, namely 10^{-12} or less of the total isotopic composition. We have mainly performed measurements involving the trace detection of the various isotopes of Kr, Tl and Xe. In particular the technique is capable to monitor the long-lived radioactive isotopes used as tracers in the well logging industry and also in the biosphere in a range, where nuclear radiation counting techniques do not have the required isotopic selectivity and sensitivity. The observed optical spectra are Doppler-free and well separated by the artificial isotope shift. This shift can be adjusted in measurements in such a way that normally overlapping lines are now free standing. In this way the measurement of accurate isotope ratios is possible, and can be used to trace the origin of the radioactive isotopes. The high sensitivity makes it possible to measure the isotopic ratios not only of noble gases, as we have demonstrated, but also for instance strontium, tritium, and other elements. Also fission materials, such as plutonium and uranium, can be detected after proper modifications and adaptation of the technique have been made. For instance, naturally occurring radioactivity, fallout from nuclear tests and nuclear accidents, or small leakages from nuclear power plants and nuclear industries can be identified as to their origin. In addition, the detection of ^{85}Kr is important, since it is produced in the nuclear fuel cycle. In the future, ^{85}Kr levels will increase as nuclear power generation is proliferated. We are in a position to adapt our on-line apparatus to analyze air samples taken from the atmosphere..

However one area of improvement still remains. This is to better develop methods to standardize our environmental sampling procedures. This problem is being solved in our present research.

For the technology transfer of our results we are working in two directions. Both applications are based on the ultra sensitive detection of ^{85}Kr , namely

1. Trace detection of ^{85}Kr to map the reservoir structure of large oil fields.
2. Trace detection of ^{85}Kr in environmental air samples to monitor nuclear activities and nuclear materials processing on a global scale.

We are in contact with the BP company for practically implementing the oil field related work and have asked for samples from their Alaskan fields. We have made contact with the Research Office of the US Airforce, for probing air samples for their ^{85}Kr content and we are in the process of submitting a proposal to obtain ongoing research support.