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High resolution NMR spectroscopy in the Earth's magnetic field

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High resolution nuclear magnetic resonance (NMR) spectroscopy at high magnetic fields has developed into a most powerful tool for the determination of molecular structures. The dream is a mobile molecular low field NMR scanner which allows the determination of molecular structures. Until to now at low magnetic fields NMR spectroscopy suffers from the low signal to noise ratio (S/N) and from the lack of access to chemical information in terms of chemical shifts and homo-nuclear J-couplings. We demonstrate that chemical analysis of liquids is possible by mobile ultrahigh-resolution ^{1}H, ^{19}F and ^{129}Xe NMR spectroscopy in the Earth's magnetic field. The ^{129}Xe chemical shift in liquids is determined in the Earth's magnetic field with a precision comparable to that obtained by superconducting magnets. The ^{1}H and ^{19}F NMR spectra allow the determination of hetero-nuclear J-coupling constants with an accuracy of a few mHz. Very fine details of the molecular structure which are not observable with conventional superconducting magnets can be discriminated. For molecules where a rare spin such as carbon ^{13}C is present the high-resolution low-field ^{1}H NMR spectrum indeed reveal all hetero- and homo-nuclear J-couplings. All these results open the door for the mobile study of molecular structures as well as for the online monitoring of chemical reactions at ultra-low magnetic fields.