The Editorial Preface

Hitoshi Ohta¹ · Toru Sakai²

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This special issue of *Applied Magnetic Resonance* deals with the THz EPR, which is becoming one of the cutting edge methods of EPR; for instance, the International Zavoisky Award 2019 was awarded to the guest editor HO as “Distinguished for his outstanding contributions to terahertz high-field EPR instrumentation and its applications in solid-state physics”. In this special issue, the definition of THz is from 0.1 to 10 THz, and the fixed THz frequency and the magnetic field sweep measurements combined with the multi-frequency THz sources will be considered as the THz EPR. No frequency domain measurement, such as the THz time domain spectroscopy under the static magnetic field, will be included because the experimental techniques are very much different and they should be considered separately.

As the resonance field of EPR is proportional to the input frequency, THz EPR requires the high magnetic field produced by the superconducting magnet or the pulsed magnetic field. However, THz EPR has many advantages which will overcome the use of high magnetic field.

1. THz EPR will give the high spectral resolution because two resonances with slightly different *g*-values will be separated beyond their line widths in the high frequency and the high magnetic field. This advantage will be especially useful for 3d–5d and 4f ion systems which have much larger line width compared to that of radical molecules.
2. Related to the above, THz EPR is required to detect EPR itself if the resonance has very large line width such as several Tesla (T).
3. If the system has a large zero-field splitting, multi-frequencies comparable to the splitting and the high magnetic field are required to observe EPR because the conventional X-band EPR will give the EPR silent result. Moreover, the precise determination of the zero-field splitting by THz EPR will enable us to understand

✉ Hitoshi Ohta
hohta@kobe-u.ac.jp

Toru Sakai
sakai@spring8.or.jp

¹ Kobe, Japan

² Kamigori, Hyogo, Japan

the system. Such zero-field splitting may come not only from the single-magnetic ion anisotropy but also may come from the spin gap of the strongly correlated spin system or the antiferromagnetic gap in the magnetic order state of the antiferromagnet.

4. Strongly correlated spin systems show rich varieties of magnetic phase transitions under the magnetic field at low temperature. To understand such magnetic phases, multi-frequency THz EPR under the high magnetic field enables us to tune the resonance into each magnetic phase and to understand the origin of magnetic phase transitions in the system.

Using above advantages, the applications of THz EPR to the quantum spin systems are discussed by S. Zvyagin, M. Hagiwara, S. Kimura, S. Demishev, and S. Okubo. Other applications to exotic systems, such as giant spin molecules, iridium oxides, and CeB₆, are discussed by H. Nojiri, V. Kataev, and A.V.Semenov, respectively.

Recently, THz EPR instrumentations are extended to multi-extreme THz EPR together with above advantages. Therefore, the high-pressure THz EPR, the highly sensitive mechanically detected THz EPR, and the ESR/NMR double-magnetic-resonance system for use at ultra-low temperatures or the surface coil for DNP-NMR are discussed by T. Sakurai, E. Ohmichi, and Y. Ishikawa, respectively.

Finally, recent theoretical approaches for THz EPR are discussed by S. Furuya, T. Sakai, and M. Matsumoto.

We want to thank the authors of this Special Issue who accepted the invitation and submitted their manuscripts in time, and referees who helped to improve the manuscripts submitted. We also want to express our gratitude to the Editor-in-Chief, Prof. Kev M. Salikhov, and the Assistant Editor, Dr. Laila V. Mosina, of Applied Magnetic Resonance for their support and encouragement, which enabled the timely publication of this Special Issue, even under the aggravated conditions of the still ongoing corona pandemic.

We decide to divide the accepted 15 papers by four Topics according to our definition of THz EPR ordering them as follows:

1. Instrumentations and methods.
2. Applications to 3d ion low-dimensional quantum spin systems.
3. Applications to other exotic systems.
4. Theory.

Inside each Topic, the articles are ordered according to the collective decision of the Invited Editors.

1. Review:

T. Sakurai et. al., High Pressure THz ESR.

E. Ohmichi et al., Mechanically Detected Terahertz Electron Spin Resonance.

Original papers:

Y. Ishikawa et al., Development of an ESR/NMR double-magnetic-resonance system for use at ultra-low temperatures and in high magnetic fields and its use for measurements of a Si wafer lightly doped with ^{31}P .

Y. Ishikawa et al., Millimeter-wave band resonator with surface coil for DNP-NMR measurements.

2. Review:

S. Zvyagin et al., Spin dynamics in quantum sine–Gordon spin chains: high-field ESR studies.

M. Hagiwara et al., Unconventional magnetic excitation and spin dynamics of exotic quantum spin systems $\text{BaCo}_2\text{V}_2\text{O}_8$ and $\text{Ba}_3\text{CuSb}_2\text{O}_9$.

S. Kimura et al., Electric Dipole Active Magnetic Resonance and Nonreciprocal Directional Dichroism in Magnetoelectric Multiferroic Materials in Terahertz and Millimeter Wave Regions.

S. Demishev et al., Staggered field in quantum antiferromagnetic $S = 1/2$ spin chain probed by high frequency EPR.

Original paper

S. Okubo et al., THz ESR study of peculiar Co pyrochlore system GeCo_2O_4 using pulsed high magnetic field

3. Review:

H. Nojiri et al., Application of THz ESR on artificial spins in magnetic molecules with giant spins.

V. Kataev, Insights into the spin-orbital entanglement in complex iridium oxides from high-field ESR spectroscopy.

A.V.Semenov et al., Heavy fermion metal CeB_6 in sub THz and THz range: the electron spin resonance and neutron scattering studies.

Original papers:

None.

4. Review:

S. Furuya, ESR theories for hidden magnetic modes in exotic quantum spin systems.

T. Sakai, EPR theories for selection rules to observe the spin gap.

Original paper:

M. Matsumoto et al., First ESR detection of Higgs amplitude mode and analysis with extended spin-wave theory in dimer system KCuCl_3 .

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