

Electron-radioactive ion collisions: theoretical and experimental challenges

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I. SCIENTIFIC ISSUE

Electrons constitute optimal probes to study several properties of atomic nuclei. Their point-like nature (which implies excellent spatial resolutions) and the fact that the electromagnetic interaction is weak and theoretically well-constrained make the reaction mechanism well under control. This allows a clean extraction of nuclear properties, much cleaner than with hadronic probes where model-dependent descriptions introduce larger uncertainties and critical ambiguities in the interpretation.

In the past, stable isotopes have been extensively and fruitfully investigated by means of collisions with electron beams [Fro87]. Up to now, the impossibility of performing ion-electron collisions with short-lived radioactive ions has hindered the extension of such studies to new regions of the nuclear chart. The information that can be potentially gathered on radii, charge and magnetic distributions, low-lying collective states, giant resonances, etc ... away from stability would be extremely valuable.

In recent years, two projects for electron-radioactive ion colliders have been put forward. The first one, initially named MUSES and based at RIKEN, has been later reshaped into SCRIT [Scr05]. It is based on the idea of trapping unstable ions by means of the electric potential created by the circulating electron beam. It is currently at the end of its completion and it is expected to reach a luminosity of around $10^{27} \text{ cm}^{-2} \text{ s}^{-1}$ for long-lived medium-mass nuclei. The second one, ELISE [Eli07], is included in the FAIR project and is based on a different concept involving two separate rings for ions and electrons. However, the fate of ELISE is uncertain as it belongs to the FAIR module that hasn't been granted funding yet.

Currently, a new project named ETIC (Electron-Trapped Ion Collider) is under study at CEA Saclay. While based on the SCRIT ion-trap concept, it aims to reach much higher luminosities (up to a factor 100 or 1000). This would allow to perform experiments with isotopes with much smaller production rates and at the same time more detailed measurements, thus increasing the physics reach in quantity and quality.

As SCRIT has produced proof-of-principle measurements [Sud09] and is moving to the first physics runs with unstable ions (scheduled in 2015-2016), the interest in electron-radioactive ion collision is increasing across the international community. The development of the ambitious ETIC project at CEA has thus a great potential impact, but at the same time poses great challenges. On the one hand, theory needs to "re-discover" techniques and ideas that have been used in the past, updated them in view of the current state of the art or even envisage new tools to tackle such issues with modern eyes. On the other hand, the design and realisation of the experimental apparatus

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require novel ideas and appears challenging in several aspects. Such technical challenges are intimately related to the physics that we would be able to access with this new machine. This workshop aims to advance both theoretical and technical discussions on the physics of electron-radioactive ion collisions, with particular attention to the aspects relevant to ETIC. It will gather theorists with interest and expertise in electron-ion collisions as well as experts from SCRIT, ELISe and ETIC teams.

References

- [Eli07] H. Simon, Nucl. Phys. A 787 102 (2007).
[Fro87] B. Frois, C. N. Papanicolas, Ann. Rev. Nucl. Part. Sci. 37, 133 (1987).
[Scr05] T. Suda, M. Wakasugi, Prog. Part. Nucl. Phys. 55 417 (2005).
[Sud09] T. Suda et al., Phys. Rev. Lett. 102 102501 (2009).

II. GOALS

The main goals of the workshop are:

1. To review the past achievements with electron scattering on stable nuclei
2. To discuss observables, and state-of-the-art theoretical methods to estimate them
3. To stimulate reflections on new observables that can be measured using electrons as a probe
4. To present the SCRIT machine and its recent results, and the ELISe project
5. To discuss challenges for the ETIC project

III. PROGRAM

The meeting takes place over three days, focusing on the physics of electron-ion collisions both with stable and unstable nuclei. Particular emphasis will be given to theoretical and experimental challenges in view of future electron-radioactive ion scattering experiments. Time slots will be allocated to discuss specific aspects of the ETIC project as well as particular points that have emerged during the workshop.

Timetable

Time	Monday 25th	Tuesday 26th	Wednesday 27th
9:15	<i>Welcome</i>		
9:30	Sick	Platchkov	Simon
10:15	<i>break</i>	<i>break</i>	<i>break</i>
10:45	Ryckebusch	Bender	Barbieri
11:30	Giusti	Péru	Vorabbi
12:15	<i>lunch</i>	<i>lunch</i>	<i>lunch</i>
14:00	Wakasugi	Napoly	Suda
14:45	Tsukada	Mosnier	Chancé
15:30	<i>break</i>	<i>break</i>	<i>break</i>
16:00	Karataglidis	Flavigny	<i>Discussion</i>

Presentations

- Densities from electron scattering: past achievements and challenges with unstable nuclei (*I. Sick*, Basel Univ.)
- Study of ground-state correlations via $(e,e'p)$ and $(e,e'2N)$ reactions (*J. Ryckebusch*, Ghent Univ.)
- NN correlations in exclusive $(e,e'p)$ and $(e,e'NN)$ reactions (*C. Giusti*, Pavia Univ.)
- The SCRIT facility at RIKEN (*M. Wakasugi*, RIKEN)
- Physics program with SCRIT (*K. Tsukada*, Tohoku Univ.)
- Proton and neutron distributions from combined (e,e) and (p,p) experiments (*S. Karataglidis*, Johannesburg)
- Highlights from electron scattering experiments at the Accélérateur Linéaire de Saclay (ALS) (*S. Platchkov*, CEA, IRFU, SPhN)
- Energy density functional studies of elastic and inelastic scattering off nuclei (*M. Bender*, IPN Lyon)
- QRPA description of collective excitations in nuclei (*S. Péru*, CEA, DAM, DIF)
- The ETIC project (*A. Chancé*, CEA, IRFU, SACM)
- The XFEL project (*O. Napolý*, CEA, IRFU, SACM)
- Spectroscopic factors from knockout and transfer reactions (*F. Flavigny*, IPN Orsay)
- The ELISe project at FAIR (*H. Simon*, GSI FAIR)
- Studying nuclear correlations with electron scattering: opportunities in exotic nuclei (*C. Barbieri*, Surrey Univ.)
- Electron scattering off nuclei with neutron and proton excess (*M. Vorabbi*, Pavia Univ.)
- Future perspectives of the SCRIT facility (*T. Suda*, Tohoku Univ.)
- Energy Recovery LINAC and high intensity sources (*A. Mosnier*, CEA, IRFU, SACM)