180° Electron Scattering at the S-DALINAC

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The contribution discusses features of the 180° system at the S-DALINAC its experimental program on transverse electron scattering with emphasis on topics of relevance for the description of neutrino interaction with nuclei. Examples discussed include the quenching of spin-isospin modes common to vector and axial coupling and M1 strength distributions for the modeling of neutral-current neutrino-nucleus interactions.

KEYWORDS: 180° electron scattering, M1 and M2 strength in nuclei, quenching of the spin-sisospin modes

1. Introduction

The Superconducting DArmstadt LINear Electron ACcelarator (S-DALINAC) [1] is presently the only electron machine worldwide with a research program focused on nuclear structure and astrophysics. The experimental nuclear astrophysics program includes e.g. electron scattering studies of the form factor [2] and the monopole transition matrix element [3] of the Hoyle state and the near-threshold transition in ^{9}Be [4, 5], as well as the extraction of level densities [6] and gamma strength functions [7] as a test of models used in large-scale reaction network calculations of the various nucleosynthesis processes.

A particular feature of the S-DALINAC is a system for 180° electron scattering [8] which allows to extract purely transverse form factors and thus the study of magnetic transitions. A long-standing problem with impact on neutrino-nucleus interactions in a variety of fields like supernova dynamics or neutrinoless double beta decay ($0\nu\beta\beta$) is the phenomenon of quenching of the axial current, in particular of the Gamow-Teller (GT) strength [9]. While electron scattering is mediated by the vector current, one can nevertheless investigate spinflip M1 transitions analog to the GT mode which provide important insights into the quenching problem [10]. Some examples of recent work and future plans in this field are discussed in this contribution.

2. 180° Electron Scattering Experiments

The S-DALINAC (Fig. 1) can be used for experiments in nuclear and radiation physics with energies between about 2.5 and 85 MeV. There are two electron guns. In the thermionic gun the electrons are emitted from a cathode and then accelerated electrostatically to an energy of 250 keV. Alternatively, a source for polarized electrons is available The required time structure of the electron beam for radio-frequency acceleration in a 3 GHz field is prepared by a chopper/prebuncher system operating at room temperature. The superconducting injector linac consists of one 2-cell, one 5-cell, and two standard 20-cell Niobium structures, cooled to a temperature of 2 K by liquid helium. When leaving the injector, the beam has an energy up to 10 MeV and can be used for nuclear resonance fluorescence experiments. Alternatively it can be bent by 180° and injected into the main accelerator section. This superconducting main linac has eight 20-cell cavities which nominally provide an