Last Experiments on the Van De Graaff

High Angular Momentum States in ^{23}Na

I.F.Wright and J.Billowes

Department of Physics, Manchester University

D.M.Pringle

Department of Nuclear Physics, Oxford University

1989 (unpublished)

One of the significant experimental developments at Oxford was the use of the MDM-2 Magnetic Spectrometer to identify highly excited gamma-decaying nuclear states with energies in the region where most states decay by particle emission [1]. In addition, an unusual and valuable feature of the Folded Tandem was the availability, using the terminal R.F. source, of good nitrogen beams with useful energies. Our last experiments on the Folded Tandem used these developments to look for highly excited gamma decaying states in ^{23}Na and ^{22}Na using the ^{12}C(^{15}N,α)^{23}Na* and ^{12}C(^{14}N,α)^{22}Na* reactions. The properties of these states provide a sensitive test of the various theoretical models for these nuclei which are complex enough to have excited states corresponding to a range of nuclear motions and simple enough for realistic theoretical calculations.

The measurements on ^{23}Na illustrate both the technique and the results obtained. The α-particles from the ^{12}C(^{15}N,α)^{23}Na* reaction were detected at 21° and momentum analysed using the magnetic spectrometer thus defining the recoil angle and excitation of the associated ^{23}Na* nucleus. A silicon detector was positioned to detect (with an efficiency close to 100%) the residual ^{23}Na nuclei from levels which γ-decay. Figure 1 illustrates the reaction kinematics and detector geometry. For this geometry, the recoils arising from particle decay to p + ^{22}Ne, α+ ^{19}F and n + ^{22}Na were detected with a lower coincidence efficiency and could normally be distinguished from the ^{23}Na recoils by their kinetic energy. Four 5"x6" NaI gamma-ray detectors were included in the experimental arrangement.

The data for the highest excitation energies is given in Figure 2 which shows spectra of all α-particles and of α-particles in coincidence with recoils whose kinetic energy is equal to that expected for ^{23}Na recoils. This coincidence spectrum consists of a combination of isolated peaks from γ-decaying levels plus a more general background from low energy neutron decay to excited ^{22}Na states (for low energy neutrons the kinetic energies of the ^{23}Na and ^{22}Na nuclei overlap). Since the events producing these two features have substantially different γ-ray multiplicities, the two contributions can be distinguished by making a comparison with the triple coincidence α-particle spectrum obtained using the same recoil gate plus the requirement of a count (of any energy) in a NaI detector. The resulting spectrum is shown shaded in Figure 2 and positively identifies the peaks at excitation energies of 14.50, 15.07 and 16.03 MeV with levels having a substantial probability for γ-decay by a high multiplicity cascade.

A theoretical shell model calculation predicts that the first two ^{23}Na excited states with angular momentum and parity equal to $19/2^+$ are at 15.09 and 16.18 MeV. The observed properties of the 15.07 and 16.03 MeV levels make them good candidates for these $19/2^+$ states.

Reference: **1.** W.N. Catford et al., Nuclear Instruments and Methods **A247** (1986) 367

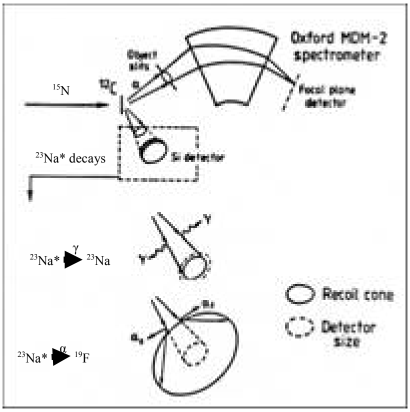

Fig. 1: Schematic illustration of the reaction kinematics and detector geometry for the ^{12}C(^{15}N, α)^{23}Na* reaction. The recoil cones for proton and neutron decay lie between those for γ- and α-decay.

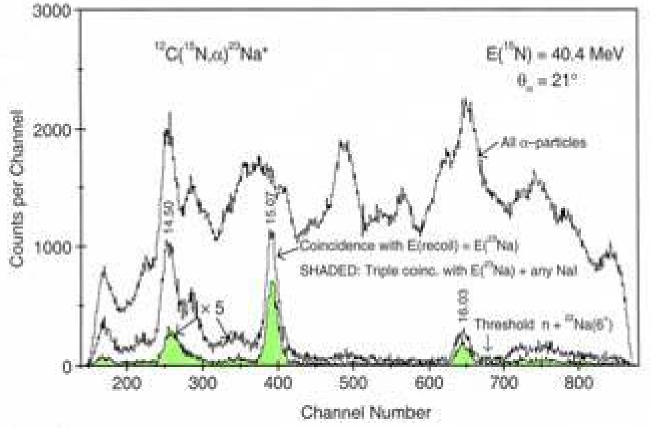

Fig. 2: Spectra, measured with the Oxford MD-2 spectrometer, of all the α-particles from the ^{12}C(^{15}N, α)^{23}Na* reaction and of α-particles in coincidence as shown

VOLUME 69, NUMBER 12 PHYSICAL REVIEW LETTERS 21 SEPTEMBER 1992

First Observation of Smith-Purcell Radiation from Relativistic Electrons

G. Doucas, J. H. Mulvey, and M. Omori
Department of Physics, Oxford University, Oxford, England

J. Walsh
Department of Physics, Dartmouth College, Hanover, New Hampshire 03755-3528

M. F. Kimmitt
Department of Physics, Essex University, Colchester, Essex, England
(Received 26 May 1992)

For its last experiment, the Oxford Van de Graaff was modified to accelerate electrons to 3.6MeV/c^2. The beam, focused to a narrow pencil, was passed over a metal grating to generate radiation in the Far Infra-red (FIR) by the Smith-Purcell (SP) mechanism -- the first such observation for relativistic particles.

The result demonstrated the potential of this effect as the basis of a tunable, high power, coherent source. Even using a less than optimal 100ma beam, the output over a range of wavelengths from 0,5 mm to 1.5 mm reached power levels ~ 10^{15} photons/sec sr at 0.1% bandwidth, comparable with a synchrotron source.

Studies have continued in collaboration with ENEA Frascati, and experiments are being proposed to investigate use of SP in the fine control of position and longitudinal beam profile for very high energy e^+ e^- linear-colliders.

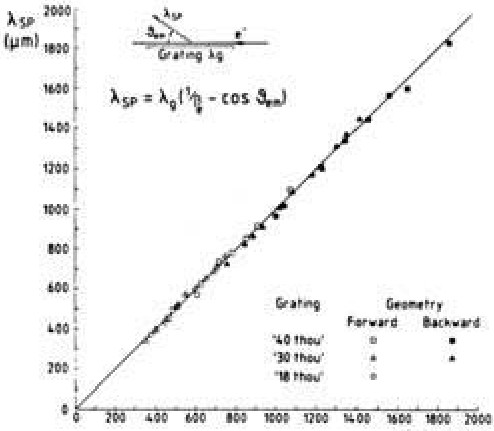

FIG. 5. Predicted Smith-Purcell wavelength, λ_{SP}, vs the observed wavelength, λ_{obs}, for the conditions indicated. The wavelengths covered by one grating (nominal 0.40-in. period) range from 467 to 1860 μm.

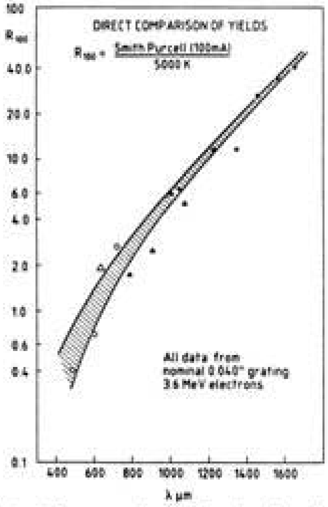

FIG. 6. A direct comparison as a function of wavelength of the Smith-Purcell signal levels form a 0.040-in. grating with those obtained from a 5000-K source under closely similar conditions.

Setting up the Linford grating and light collection assembly.

Van de Graaff Control Room