EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

[Letter of Intent] to the ISOLDE and Neutron Time-of-Flight Committee

Digital TDPAC with ^{19}O in Cobalt Metal

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Abstract: ^{19}O is an interesting PAC isotope which decays to ^{19}F. It provides access to information about the local structure of the oxygen sublattice in many functional oxides or as impurity in metals or other materials, especially oxygen sensitive materials. Due to the short half life of 26.91 seconds, measurements have to be taken on-line and are quite challenging. On-line measurements have the disadvantage that defects play an important role. With the following measurement a new method will be tried out first time to synchronize a circular on-line measurement with the beam and separate a defect PAC spectrum from an annealed spectrum using most recent developed fully recording digital PAC spectrometer.

Requested shifts: [x] shifts, (split into [y] runs over [z] years)

1 Introduction: $^{19}O/^{19}F$ as a PAC Probe

Perturbed Angular Correlation (PAC) is a Technique to study the local structure in materials. Most common known and good working isotopes for PAC are metals and used to study properties in all sort of materials. Metal oxide make a large scale of materials in the world and many todays functional materials are modified oxides. Therefore studying the local structure of the oxygen sublattice in oxides has a huge potential of interest. The only for PAC available source is ^{19}O that decays to ^{19}F. The half life of ^{19}O is rather short with 26.91 seconds. The ^{19}F has a sufficient good populated cascade with an intermediate (sensitive) level of 89.3 ns and easy to separate γ-energies.

2 Synchronized Circular On-Line Measurement with Digital TDPAC-Spectrometer

Due to the short half life of ^{19}O, measurements have to be taken on-line. However on-beam measurements have the disadvantage that radiation defects are continuously introduced into the material. Especially the most recent implanted high dose of ions will contribute intensively to the PAC spectrum compared to the ions already longer in the sample, so that radiation defects will be expected to be seen in that measurement. The annealing time in a sample depends on activation energies and therefore diffusion, which are dependant on temperature. In case of a sufficient high chosen temperature, the annealing time to heal defects can shrink to a few seconds. If the measurement is executed with a pulsed beam and the recording of the PAC spectrum is synchronized with it in that way, that the required time for implantation plus annealing and after the annealed sample are separately recorded or time-stamped to be separated out of the data-stream after, it will be possible to obtain two separate spectra or only a spectrum of the annealed sample, when the implantation and annealing time are too short for a full spectrum.
The recently developed digital TDPAC-spectrometer in Braunschweig University of Technology founded by the BMBF and now guided by RWTH-Aachen is a fully recording instrument. It records each γ-event as time and energy values separately on each channel. A minimal calibration is required before a measurement and is just mainly limited by configuring the detectors once which can be performed offline. For PAC typical settings, such as energy windows and time windows, are configured after the measurement has been started. They can be optimized as often as required, as all raw data stay available for detailed analysis.
As the instrument is fully run and controlled by software, implementing an interrupt for an external start/stop or a pulser for controlling the beam gate, is a minor and simple change in the software. According to the ISOLDE setup an external gate opener/closer can be setup and the PAC-spectrometer will request the beam according to it's measuring cycle status. Implementing this is part of the actual BMBF project.
Currently this new instrument is extended from a four detector machine to eight detectors with a flexible to choose channel number. As only a few electronic modules are missing now and they will be included during the winter time, we expect that our currently running four detector machine will be ready to run during spring time with full eight detectors to

increase the efficiency of this planned measurement and in fact short the time compared to a standard four detector machine. For the on-line experiment we would choose a planar setup. Beam time plus annealing time and the annealed sample will be recorded in a separate spectrum. According to the life time of ^{19}O, the cycle has to repeat every 1-2 minutes. ISOLDE can provide a beam of carbon monoxide with about 10^7 atoms per second, which is above the level which is needed for a continuously on-line measurement.

3 Oxygen in Cobalt Metal

For the case of principle study of a circular on-line measurement, we choose cobalt metal in form of single crystal as simple magnetic material, of which we can expect a good PAC spectrum, known from experiments with other PAC-isotopes. However studying oxygen in cobalt metal might be still an interesting goal.

Summary of requested shifts: 3-4

References

Appendix

DESCRIPTION OF THE PROPOSED EXPERIMENT

The experimental setup comprises: (*name the fixed-ISOLDE installations, as well as flexible elements of the experiment*)

Part of the	Availability	Design and manufacturing
SSP-GLM chamber or SSP-GHM chamber	☒ Existing	☒ To be used without any modification
Part 1: Implantation Chamber	☒ Existing	☐ To be used without any modification ☒ To be modified: Detectors attached
	☐ New	☐ Standard equipment supplied by a manufacturer ☐ CERN/collaboration responsible for the design and/or manufacturing
Part 2: digital PAC-spectrometer	☒ Existing	☐ To be used without any modification ☒ To be modified: as described
	☐ New	☐ Standard equipment supplied by a manufacturer ☐ CERN/collaboration responsible for the design and/or manufacturing
[insert lines if needed]		

HAZARDS GENERATED BY THE EXPERIMENT (if using fixed installation:) Hazards named in the document relevant for the fixed [COLLAPS, CRIS, ISOLTRAP, MINIBALL + only CD, MINIBALL + T-REX, NICOLE, SSP-GLM chamber, SSP-GHM chamber, or WITCH] installation.

Additional hazards:

Hazards	[Part 1 of experiment/ equipment]	[Part 2 of experiment/ equipment]	[Part 3 of experiment/ equipment]
Thermodynamic and fluidic			
Pressure	[pressure][Bar], [volume][l]		
Vacuum			
Temperature	[temperature] [K]		
Heat transfer			
Thermal properties of materials			
Cryogenic fluid	[fluid], [pressure][Bar], [volume][l]		
Electrical and electromagnetic			
Electricity	[voltage] [V], [current][A]		
Static electricity			

Magnetic field	[magnetic field] [T]		
Batteries	☐		
Capacitors	☐		
Ionizing radiation			
Target material [material]			
Beam particle type (e, p, ions, etc)			
Beam intensity			
Beam energy			
Cooling liquids	[liquid]		
Gases	[gas]		
Calibration sources:	☐		
• Open source	☐		
• Sealed source	☐ [ISO standard]		
• Isotope			
• Activity			
Use of activated material:			
• Description	☐		
• Dose rate on contact and in 10 cm distance	[dose][mSV]		
• Isotope			
• Activity			
Non-ionizing radiation			
Laser			
UV light			
Microwaves (300MHz-30 GHz)			
Radiofrequency (1-300 MHz)			
Chemical			
Toxic	[chemical agent], [quantity]		
Harmful	[chem. agent], [quant.]		
CMR (carcinogens, mutagens and substances toxic to reproduction)	[chem. agent], [quant.]		
Corrosive	[chem. agent], [quant.]		
Irritant	[chem. agent], [quant.]		
Flammable	[chem. agent], [quant.]		
Oxidizing	[chem. agent], [quant.]		
Explosiveness	[chem. agent], [quant.]		
Asphyxiant	[chem. agent], [quant.]		

Dangerous for the environment	[chem. agent], [quant.]		
Mechanical			
Physical impact or mechanical energy (moving parts)	[location]		
Mechanical properties (Sharp, rough, slippery)	[location]		
Vibration	[location]		
Vehicles and Means of Transport	[location]		
Noise			
Frequency	[frequency],[Hz]		
Intensity			
Physical			
Confined spaces	[location]		
High workplaces	[location]		
Access to high workplaces	[location]		
Obstructions in passageways	[location]		
Manual handling	[location]		
Poor ergonomics	[location]		

Hazard identification:

Average electrical power requirements (excluding fixed ISOLDE-installation mentioned above): [make a rough estimate of the total power consumption of the additional equipment used in the experiment]