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ACCEL, a program for data acquisition *

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ACCEL is a computer program for data acquisition and experimental control used at the University of Toledo's Heavy Ion Accelerator facility, THIA. ACCEL is written in Pascal and runs on an IBM PC in conjunction with a Keithley Series 500 Data Acquisition System for data collection in beam–foil studies of the lifetimes of excited atomic states. In addition to photon counting, foil positioning and wavelength scanning may be programmed. Collected data are displayed graphically, printed as collected, and stored on disk for later analysis. The program allows flexible control and is designed to allow new functions to be added easily.

1. Introduction

In the modern physics laboratory, a computer is routinely used for controlling experimental parameters and acquiring data for all but the simplest of experiments. At the University of Toledo's Heavy Ion Accelerator facility, THIA, these tasks are performed by the program, ACCEL, executing on an IBM PC computer that is connected to a Keithley Series 500 Data Acquisition System. Running on this relatively simple hardware, ACCEL provides for four scaler channels (e.g. for photon counting) while scanning experimental parameters. The simultaneous scanning of experimental parameters such as the wavelength and viewing distance after excitation is programmable via a simple user interface.

ACCEL was designed primarily to take spectra and measure lifetimes of excited electronic states in atoms and ions using the beam–foil technique [1]. In this technique, ions are excited while passing through a thin foil, and the light emitted as the ion de-excites is observed. Normally these photons are detected via a spectrometer by a photomultiplier tube. Lifetimes of atomic states are measured by studying the number of photons emitted as a function of time after excitation. Because the beam is moving at a fixed velocity, this variation in time is accomplished by varying the distance between the exciter-foil and the entrance slits of the spectrometer. For these experiments, the control tasks are driving stepping motors to set both the wavelength on a spectrometer and distance between the exciter-foil and the entrance slits of the spectrometer, while the data collection task is reading several scalers after some user selected normalization condition is satisfied. Scanning high voltage power supplies through DACs and reading ADCs are also possible.

2. The hardware

The hardware platform on which ACCEL was designed to execute was an IBM PC (8088 running at 4 MHz) with a hard disk, a printer, and a Keithley Series 500 Data Acquisition System. The Keithley system is connected to the computer by a proprietary card and is mapped into the computer's high memory. All of the control and data acquisition tasks are performed by various modules (user installable cards) in the Keithley system. Digital outputs provide a direction signal and the pulse train used to drive stepping motors. The pulse train is ramped during acceleration and deceleration of the motors. From a digital to analog converter (DAC), an analog output in the range of 0 to −5 V is used to control high voltage power supplies for an electrostatic energy analyser that can be used to measure the energy of the ion beam [2]. A 14 bit analog to digital converter (ADC) is available for analog inputs.

Four TTL-compatible pulse counters are used for data acquisitions. The sources for the pulses are: a 100 kHz crystal oscillator; a current digitizer connected to the Faraday cup for the ion beam; a photomultiplier tube (PMT) at the exit slits of the spectrometer; and a second PMT used to monitor the total light produced in the beam–foil interaction. These pulse counters require software monitoring because an overflow oc-

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curs after 65 535 counts. In the absence of a multitasking operating system, this constant software monitoring limits data analysis during data collection to data printing and on-screen data plotting. Because these functions create a small amount of system dead time between collecting data points, these functions may be disabled by the user but this dead time is usually small compared to that required to change the wavelength or foil position between data points.

3. The program

ACCEL consists of approximately 6600 lines of Turbo Pascal 4.0 [3]. The program is divided into 15 "units" and several "include files". Units may be compiled separately and interact only through a declared interface section, which reduces development time and decreases side effects between pieces of code. The modular nature of the program units in Turbo Pascal also increases the reusability of the associated code.

Because all of the program's interaction with the Keithley Series 500 Data Acquisition System is contained in one unit, the program could readily be converted to other PC-compatible systems. Each module in the Keithley system is addressed as if it were two bytes of memory by the program using absolute variables. Other units handle such functions as graphing, printing, disk services, and managing the actual data acquisition cycle.

4. The user interface

A good user interface for the data acquisition program should allow experiments to be set up quickly, as well as to minimize the time and effort spent learning to use the program. Much of the code for ACCEL provides the user interface, which consists of a tree of menus with most selections available by a single keystroke. This interface allows the user to enter the current experimental setup, calculates estimates of associated parameters, and provides automatic logbook recording, real-time graphics, as well as data printing and storage on diskette. A small programming language allows the user to specify the sequence of wavelengths and foil-to-slits distances for the experiment. These control programs and the setups can be saved and loaded later.

Upon starting ACCEL, information is requested about the current experiment such as the ion used and its energy, the characteristics of the foil, the spectrometer setup, and current physical positions for the foil position and spectrometer wavelength. From this information, various interactions of the ion beam with the foil are estimated, including: ion energy loss; angular scatter; foil life expectancy; and ion charge-state distribution after the foil. This information is useful for both planning an experiment and analysing data. The estimated ion velocity after exiting the foil is used as the conversion factor from foil position to time after ion excitation and the user may choose to specify the foil position as a time.

For testing of the equipment, the wavelength and foil positions may be set from within the program. To guide the reconnecting detectors, a brief summary of the wiring is available. Quick testing of the electronics is possible by using the special command to collect data for one second. The collected data are normally graphed on the screen and printed as collected. At the end of a run, data may be saved to disk. A logbook page based on the entered description of the experiment and the range of wavelength and foil position studied may be printed.

A miniature interpretive programming language is used to control the experiment. The available commands include: set the spectrometer to a given wavelength; increment the wavelength; set the foil position; increment the foil position; collect on data point; null (to temporarily remove a line of the program); and a loop–endloop structure. Nesting of the loop–endloop structures is possible and up to 256 program steps are allowed. Together these commands form a minimum set required for complex parameter scanning during an experiment. For example, the user may vary the wavelength or foil position step size from region to region as appropriate. An editor is provided for creating programs and a program syntax is verified when the editor is exited. Below is an example of a simple program that collects data at a grid of five wavelength by ten foil positions. The foil position is measured in stepping motor pulses and the wavelength in ångströms:

```
 1 set wave to 1300
 2   loop for 10
 3   set wave to 4900
 4      loop for 5
 5      data collection
 6      step wave by 0.5
 7      endloop
 8   stepfoil by 100
 9   endloop
10 quit.
```

Scanning both wavelength and foil position may be necessary when studying the lifetimes of atomic levels associated with unresolved or poorly resolved line blends as investigated for quartet states in neutral carbon in ref. [4]. If different components of the blend have different lifetimes then the shape of the blend will change with time after excitation as controlled by the foil position. Scanning both these parameters in a single run decrease variations caused by beam instability or foil degradation.

5. Conclusions

Accel is a program that allows flexible control of an experiment on relatively simple hardware. The source code and user's manual is available from the authors.

References

[1] L. Kay, Phys. Lett. 5 (1963) 36;
S. Bashkin, Nucl. Instr. and Meth. 281 (1964) 88.

[2] R.M. Schectman et al., Nucl. Instr. and Meth. B31 (1988) 253.

[3] Turbo Pascal is a register trademark of Borland International, Inc., 4585 Scotts Valley Dr. Scotts Valley, CA 95066, USA.

[4] R.R. Haar et al., Phys. Lett. A141 (1989).