Summer Nuclear Institute at Triumf 2002
Nuclear Astrophysics : Observation, Experiment, Theory

June 10 - 21, 2002

TRIUMF, Vancouver, Canada

Program

Nuclear astrophysics is concerned with the impact and influence of nuclear structure and nuclear reactions on astrophysical processes from the beginning of the universe in the big bang through the evolution of stars. New astronomical observations, new accelerators and detection techniques, and fast growing computational power provide unprecedented opportunities for major advances in our understanding of the cosmos. The many connections between astronomical observations, astrophysical modeling efforts, nuclear structure and reaction theory, and experimental nuclear data provide also major challenges for researchers in the field of nuclear astrophysics. It is the goal of this year's summer school to give an introduction to this exciting field. Astrophysical phenomena and observations that might benefit from new or improved nuclear physics input will be covered; an overview over experimental goals, techniques, and facilities will be given, and various theoretical approaches to nuclear structure and reactions will be discussed.

Featured Speakers

- L. Buchmann, TRIUMF, Vancouver, Canada
- C. Johnson, San Diego State University, San Diego
- D. Lambert, University of Texas at Austin, Austin, USA
- K. Langanke, Aarhus University, Aarhus, Denmark
- G. McLaughlin, North Carolina State University, Raleigh, USA
- B. Meyer, Clemson University, Clemson, USA
- C. Rolfs, Universität Bochum, Bochum, Germany
- H. Schatz, NSCL, Michigan State University, East Lansing, USA
- A. Shotter, TRIUMF, Vancouver, Canada
- K. Snover, University of Washington, Seattle, USA
- E. Vogt, TRIUMF, Vancouver, Canada

Schedule

	Monday June 10	Tuesday June 11	Wednesday June 12	Thursday June 13	Friday June 14
8.00– 9.00 am	Registration				
	Chair: Escher	*Jennings*	*Buchmann*	*Hackman*	*Vogt*
9.00–10.00 am	Shotter	Rolfs	Rolfs	Rolfs	Rolfs
10.00–11.00 am	Rolfs	Johnson	Johnson	Johnson	Johnson
11.00–11.30 am	*coffee break*	*coffee break*	*coffee break*	*coffee break*	*coffee break*
11.30–12.30 am	Snover	Snover	Lambert	Lambert	Lambert
12.30– 2.00 pm	*pizza reception*				
	Chair: Hackman	*Jackson*	*Jennings*	*Buchmann*	*Sarazin*
2.00– 3.00 pm	Lambert	Lambert	tutorials	tutorials	tutorials
3.00– 4.00 pm	tutorials	tutorials	tutorials	tutorials	tutorials

	Monday June 17	Tuesday June 18	Wednesday June 19	Thursday June 20	Friday June 21
	Chair: Hackman	*Jennings*	*Buchmann*	*Poutissou*	*Jackson*
9.00–10.00 am	Langanke	Vogt	McLaughlin	McLaughlin	McLaughlin
10.00–11.00 am	Meyer	Meyer	Meyer	Buchmann	Buchmann
11.00–11.30 am	*coffee break*	*coffee break*	*coffee break*	*coffee break*	*coffee break*
11.30–12.30 am	Langanke	Langanke	Schatz	Schatz	Schatz
12.30– 2.00 pm					
	Chair: Buchmann	*Jennings*	*Hackman*	*Chen*	*Jennings*
2.00– 3.00 pm	tutorials	TRIUMF Tour	tutorials	tutorials	tutorials
3.00– 4.00 pm	tutorials	tutorials	tutorials	tutorials	tutorials
4.00– 6.30 pm					
6.30– 9.30 pm				*banquet*	

Contents of Lectures

Lothar Buchman, TRIUMF
Selected problems in low energy nuclear scattering

Outline: Some problems where theoretical treatment of low energy nuclear cross sections is necessary will be presented, both discussing experimental procedures and the theoretical treatment. After outlining the minimal theory, β-delayed particle processes as well as reaction cross sections will be discussed.

Lecture 1: Introduction, the β-delayed particle decays of ^{16}N and ^{9}C
Lecture 2: Reaction cross sections: ^{12}C(α,γ)^{16}O, ^{21}Na+p

Calvin Johnson, San Diego State University
The nuclear shell model, with applications to astrophysics

Outline: The nuclear shell model is one of the most important microscopic approaches to nuclear structure. After a general overview I will emphasize practical aspects of shell model calculations and survey results relevant to astrophysics.

Lecture 1: One at a time: the noninteracting shell model.
Lecture 2: Mixing it up: the interacting shell model.
Lecture 3: Talking to leptons: how to calculate weak and electromagnetic transitions.
Lecture 4: Cooking in the cosmic kitchen: applications in astrophysics.

David Lambert, University of Texas at Austin
Nuclear astrophysics – observations

Lecture 1:

- Astrophysics of nuclear astrophysics:
  - Nuclear energy sources and stellar structure.
  - Nucleosynthesis.
- The compositions of astronomical objects:
  - Solar system: meteorites, solar atmosphere.
  - Stars.
  - Interstellar gas.
- Introduction to the physics of stellar atmospheres.
- Introduction to line formation and abundance analysis.

Lecture 2:

- Introduction to the physics of stellar interiors.
- An observer's view of stellar evolution.

Lecture 3:

- Origins of the heavy elements:
  - Red giants and the s-process.
  - Observational insights to the r-process.

Lecture 4:

- Origins of the light elements: Li, Be, and B.

Lecture 5:

- Chemical evolution of stellar systems:
  - The galaxy.
- Unfinished business:
  - Stellar atmospheres.
  - Stellar structure.
  - Stellar systems.

Karlheinz Langanke, Aarhus University
Supernovae and Nuclear Physics

Outline: At the end of their evolution massive stars run out of nuclear fuel. As a consequence the core of the star collapses triggering a (type II) supernova. Simulating core-collapse supernovae on a computer is a great challenge requiring an interplay of several physics disciplines. Nuclear physics plays a key role. The lectures will introduce the nuclear physics inputs needed in a supernova simulation. Increased computer power and more sophisticated nuclear models have recently allowed to improve the nuclear physics relevant for supernovae. These include electron captures and beta decays at stellar conditions, neutrino-nucleus reactions, neutrino opacities in dense nuclear matter etc. Core collapse supernovae might also be a site of the r-process. In such a dynamical scenario beta decays and perhaps neutrino-nucleus reactions are crucial. Supernovae are also the site of neutrino nucleosynthesis.

Gail McLaughlin, North Carolina State University
Neutrino oscillations: theory and application to astrophysics

Outline: Results of recent experiments, such as SNO and SuperK, have indicated that neutrinos have mass. This exciting result is inferred from evidence for neutrino oscillations. I will discuss the theory behind this result, and implications of the recent data.

Lecture 1: Basics of matter enhanced and vacuum neutrino oscillations.
Lecture 2: Putting it all together: the neutrino mixing matrix.
Lecture 3: Supernova neutrinos: What can we learn if we detect them and how do neutrino oscillations fit in the picture?

Brad Meyer, Clemson University
Explosive nucleosynthesis

Outline: Explosive nucleosynthesis in stars and the early universe is a nexus for nuclear physics, astrophysics, and particle physics. I will present a general perspective on explosive nucleosynthesis in the paradigm of constrained equilibria.

Lecture 1: Introduction: explosive nucleosynthesis and constrained equilibria.
Lecture 2: The usual suspects.
Lecture 3: New surprises in an old field.

Claus Rolfs, Ruhr-Universität Bochum
Experimental nuclear astrophysics, an introduction

Outline: Energy source in the sky: how does our sun work?
Stellar evolution: curriculum vitae of a star.
Complications: dredge-up, mass-loss, binaries.
Consistency check: solar neutrinos.
Solar model: helio-seismology.
Nuclear reaction rates: experimental aspects.
Key reactions in stellar burning: a never-ending problem?
Go underground: LUNA.
The life elements: ERNA.
Hot/explosive burning: exotic ion beams.
Electron screening: a pioneering topic.
Big-bang nucleosynthesis: challenges.
Cosmic chronology: nuclear quests.

Hendrik Schatz, NSCL, Michigan State University
Experimental nuclear astrophysics with radioactive beams

Lecture 1: X-ray bursts and pulsars - nuclear physics at the extremes – I
Lecture 2: X-ray bursts and pulsars - nuclear physics at the extremes – II
Lecture 3: Nuclear astrophysics with fast fragmentation beams

Alan Shotter, TRIUMF
Nuclear astrophysics - a general view and the TRIUMF connection

Outline: This will be a general talk which will aim to identify the main mission of Nuclear Astrophysics and in particular how the TRIUMF laboratory can contribute to this mission.

Kurt Snover, University of Washington, Seattle
The ^{7}Be(p, γ)^{8}B reaction and solar neutrinos

Outline: I will describe our present knowledge of the astrophysical rate for the ^{7}Be(p, γ)^{8}B reaction, and implications for our understanding of the solar production rate of high energy neutrinos and for neutrino physics. I will use this subject to explore some of the general physics issues connected to these topics.

Erich Vogt, TRIUMF
Nuclear halo states

Outline: Nuclear halo states are unusual states which involve very loosely bound nucleons - typically one or more neutrons extending far beyond the normal nuclear radius. Of course near the drip lines nucleons extend to large distances but even in the valley of stability halo states are expected to be relatively common. The definition of such states and the criterion for their existence will be discussed as well as their impact on nuclear physics and astrophysical reaction rates.

Organizing Committee

Jutta Escher (escher@triumf.ca), Phone: +1-604-222-1047 x. 6540
Byron Jennings (jennings@triumf.ca), Phone: +1-604-222-7428
Lothar Buchmann (lothar@triumf.ca), Phone: +1-604-222-7403
Greg Hackman (hackman@triumf.ca), Phone: +1-604-222-7441

Conference coordinator: Elly Driessen (snit@triumf.ca), Phone: +1-604-222-7532
Web master and tech support: Martin Comyn (comyn@triumf.ca), Phone: +1-604-222-7427

SNIT 2002 web site: **http://www.triumf.ca/snit**