### Research Hub for Fundamental Symmetries, Neutrinos, and Applications to Nuclear Astrophysics:

The Inner Space/Outer Space/Cyber Space Connections of Nuclear Physics

- Our scientific focus: why these themes?
- The Hub's philosophy, organization: helping to create a next generation of independent, interactive, broadly educated young researchers
- **Our group:** our collaborative science, our mentoring record (George)

Attending: coPIs Baha Balantekin, George Fuller, and Gail McLaughlin

## **Scientific Focus**

**Several of the most important advances** in fundamental physics of the past 25 years have come from inner space/outer space connections:



**solar neutrinos:** discovery of neutrino mass, flavor mixing

**Dark matter:** discovery that the dominant form of matter in our universe, responsible for the cosmological structure we see, is outside our standard model, as yet unidentified



DAMA/Libra

## **Dense matter:** emergence of new tools for probing the properties of ultra dense nuclear matter



nuclear EoS

#### These advances are changing the directions of subatomic physics

Neutrino Physics:LBNF will be the primary on-shore focus of particle physics<br/>over the next 20 years;<br/>The search for neutrinoless ββ decay and lepton number<br/>violation is the next major project for nuclear physics

Nucleosynthesis: FRIB will soon map out the masses and beta decays of isotopes that form the ground states of the nuclear matter found in SNe and NS mergers

Dense matter: The discoveries of massive neutron stars, a double pulsar, and gravitational waves are creating new connections between strong-field astrophysics and exotic nuclear matter

Dark matter: G2 direct detection experiments are now underway, and about a dozen additional technologies are being developed; progress in near-field cosmology is creating new connections between nucleosynthesis and structure at the galactic scale

#### The problems are interconnected:

Different aspects of fundamental NP controlling astrophysical environments



Fundamental NP microphysics  $\Rightarrow$  HPC modeling  $\Rightarrow$  astrophysics observables

#### This field offers NP exceptional opportunities for recruitment, as well as exceptional professional development opportunities for the recruits

- □ The problems are exciting:
  - exotic NS merger and SN environments, prodigious fluxes and energies
  - deep questions, such as the origin of particle masses, the nature of dark matter, nucleosynthesis, symmetries like lepton number, flavor
     Young people are drawn to the field
- The "Quarks to the Cosmos" theme is real: The field connects our laboratory programs (FRIB, JLab, RHIC, ββ decay) to exciting astrophysics
- Major discoveries have been made and are likely to continue: new observing tools like LIGO are emerging, LS survey technologies are advancing by orders of magnitude, not incrementally
- The rapid advances in HPC will allow us to make the "quarks to the cosmos" connections required by increasing precise and detailed data
- This kind of interdisciplinary NP training prepares young researches for success: young nuclear physicists trained in this area have natural connections to other subfields, easing the transition into faculty jobs

# We have focused on the Q2C aspects of NP symmetries, where the need for growing the field seems most acute

- Opportunities at the particle/nuclear/astrophysics intersection are growing rapidly, driven by experimental and observational successes
- Our focus complements existing efforts, emphasizing the intersection between fundamental symmetries and astrophysics
  - DOE Topical Center to focus on ββ decay matrix elements, edm's, hadronic PNC
  - SciDAC: LQCD work on neutron edms, hadronic PNC
  - major facilities support relevant postdoctoral and faculty bridge programs

Our Hub's focus is well aligned with the six fundamental physics/astrophysics questions identified in the 2007 LRP executive summary:

- What is the origin of neutron stars and dense nuclear matter?
- What is the origin of the elements in the cosmos?
- What are the nuclear reactions that drive stars and their explosions?
- What is the nature of the neutrinos, and how have they shaped the evolution of the universe?
- Why is there now more visible matter than antimatter in our universe?
- What are the unseen forces that were present at the dawn of the universe but disappeared from view as the universe evolved?

## The Hub's Philosophy and Organization

- Considered attributes of some successful PD programs: Einstein, Hubble, INT
  - recruit broadly, maintain flexibility in placement
  - $\circ$  selection process that emphasizes quality, not fit to an existing program
  - empower the PD to make choices about his/her science: treat as individual investigators, not as an assistant to some faculty member
  - $\circ$  showcase the individual: visibility in community meetings
  - prepare the PD to succeed at the faculty level, and help launch the PD to that next step
- Challenges:
  - $\circ$  accomplishing this with limited resources, in a community that is dispersed
  - implementing the program in a way that addresses PD personal needs benefits, spousal needs, mentoring, and scientific goals - in a simple way
     oversight that places PD needs first
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- Our Hub plan:
  - select outstanding faculty with established records of research, collaboration, community involvement, and postdoc mentoring
  - couple them in ways that produce a PD environment beyond that possible in any one institution







- The recruitment will be as "Hub Fellows" with those selected having the freedom to select from among the hub's institutions - and we will look both within NP and on its boundaries
- Candidate selection will done by the 15 Hub members. Short-listed candidates will be interviewed at a Hub site and visit a Hub center. Seminars will be broadcast. Candidate selection will then be completed and offers made.
   All selected candidates are Hub Fellows, though resident at their selected sites

Year 1	Year 2	Year 3	Year 4	Year 5
Hub Site 1	Hub Site 1	Hub Center 1		
Hub Site 2	Hub Site 2	Hub Center 2		
Hub Site 3	Hub Site 3	Hub Center 3		
	Hub Site 4	Hub Site 4	Hub Center 1	
	Hub Site 5	Hub Site 5	Hub Center 2	
		Hub Site 6	Hub Site 6	Hub Center 1
		Hub Site 7	Hub Site 7	Hub Center 2
		Hub Site 8	Hub Site 8	Hub Center 3

Year 0 corresponds to the first available fall recruitment cycle















#### **Recruitment, selection, placement**

- selection process is designed to attract the widest possible pool of candidates, and provide the successful candidate with the maximum amount of choice
   this is often important is building a diverse pool of applicants
- their choices will be informed: in addition to their visits, candidates will have access to a web site that provides detailed information about the various sites — both scientific and quality-of-life issues
- the plan has great flexibility in accommodating PD needs
  e.g., we could accommodate a PD who accepts our offer, but needs time to identify the best site, because of a spouse/partner career
- PDs are Hub postdocs, and will be part of an inter-site collaboration from day one, typically with both a local mentor and an off-site mentor
  - mentors would work together to help advance the PD's development, and would serve both as both role models and scientific advisors
- we will have mechanisms in place to identify any problems that might arise, as well as the flexibility to make adjustments, should they be necessary

Hub sites will take the lead in integrating the PDs into the Hub's collaborative structure

- two-year affiliation focused on PD's scientific development
- $\circ$  PDs will have opportunities to travel and interact across the Hub

Hub centers will play an important role in PD career development

 PDs will be embedded in three strong institutions, where they can build connections with experiment, observation, and sister theory subfields
 preparation for the step to faculty status in a research university
 "launching pads" for the PDs, as they take their next steps

Sites and centers will coordinate efforts to help PD professional advancement

- the center-piece is our collaborative, interdisciplinary research
- we will help introduce PDs to the community by seeking speaking opportunities, involving them in the workshops we propose and organize, encouraging them to lead activities in our annual meeting, etc.
- our web site will be a clearinghouse for information that can help our PDs professionally, as well as support them personally (see proposal)

Through inter-institutional visits, modern conferencing tools, and broadcast seminars, we will aim to make the Hub function as a true center

#### Administrative issues

• Hub postdoctoral appointments will be made through UC Berkeley

- simplifies administration, avoiding subcontracts and associated costs
- Hub proposal approved for a 26% off campus rate
- $\circ$  benefits are then continuous throughout the three-year term
  - UC medical, dental, vision, life, disability insurance includes postdocs stationed out of state (HealthNet)
  - the out-of-state option is a PPO, with out-of-network options for a higher deductible; have checked PP availability, appears excellent
- although titles vary, the postdocs will also have an official association at their host university: visiting scholar, postdoc-paid-by-others, ...
- requested budget includes salaries and benefits, Hub Fellow travel and interview costs, Hub annual meeting costs, modest relocation costs (2), and modest equipment costs
- the budget covers 75% of costs of our proposed program (24 postdoc-years)
  group has agreed to support 25% from our local grants/sources
  other funding options also being explored

 Task division: PD search committee (charged with initial short-list selection); workshop committee (INT, KITP, other opportunities); annual meeting committee;

professional development committee (keeps PDs abreast of teaching/outreach opportunities, faculty openings, due dates for named fellowships, talk and workshop opportunities)

 $\circ$  Advisory committee: sounding board, source of critical advice

- Gordon Baym, U. Illinois
- Anna Frebel, MIT
- Boris Kayser, FermiLab
- Michael Thoenessen, MSU