Contribution ID: **355** Type: **Invited Presentation**

Origin of ultrahigh-energy cosmic rays in Binary Neutron Star Collisions and the crucial roles of Nuclear Physics

The presentation will begin with a concise overview of the key observational evidence constraining the properties of UHECRs, and why the evidence points to binary neutron star (BNS) mergers as their source. The main topic of the talk is predicting the spectrum and composition of UHECRs in the BNS merger scenario. It is possible to do this in unprecedented specificity thanks to the well-constrained initial conditions after the merger. I will argue that the UHECRs with highest energies are produced in the magnetized outflow away from the jets, contrary to pre-conceived assumptions. I calculate the spectra (including the peak energy) of different A,Z nuclei; the predictions are in good agreement with data. The possible existence of a secondary, higher energy component of protons and/or helium accelerated in the jets is noted and their spectra are predicted.
Nuclear physics plays a critical role in three key aspects of UHECR production:
1) The neutron star equation of state governs the longevity of the transient hyper-massive neutron star, whose lifetime determines the total energy of UHECRs produced.
2) Nucleosynthesis in the expanding ejecta determines the initial distribution of atomic masses. Outside the jets, these are primarily r-process nuclei. After about a day of continued expansion, the conditions for accelerating the highest energy UHECRs are reached.
3) The first stage of acceleration, beginning after 1-10 seconds of expansion, produces a seed population of nuclei with energies above 100 MeV. Its distribution of {Z,A} reflects the r-process abundances and the dependence of initial energization on {Z,A} —however this does not fix the relative amounts of different nuclei in observed UHECRs. Instead, there is a period in which these seed CR nuclei collide with the bulk, unaccelerated nuclear outflow, breaking up into a broad spectrum of lighter CRs. This is then the population which is accelerated to be the UHECRs. So, the nuclear physics of breakup of heavy ions will be critical to predicting the ultimate mix of nuclear masses in UHECRs.

Muiltimessenger consequences and probes of this scenario will also be discussed.

Author: FARRAR, Glennys (New York University)

Presenter: FARRAR, Glennys (New York University)

Session Classification: Plenary Session

Track Classification: Astroparticle Physics and Synergies with Nuclear Physics