Resumé of main key questions

- *Keep significant efforts in models* (HADES, Sorensen, Spirit, Zhao-qing, INDRA&FAZIA): flow, clusters, iso-diff/iso-drift, QP breakup, n/p-like obs., etc…. both IE and RE are important
- *Importance of scanning*: masses, Ebeam, particle species – data vs models
- *Errors in model dependencies*?
- Flow observables: where are we (after the 2002 paper by Danielewicz, Lynch, Lacey)?
- Link between clusters in HIC and pasta structures in NS
- Physics and detectors at *FRIB*
  - Participant and spectator physics important? Thresholds, ToF, …
  - New neutron detection technologies?
  - need for *TPC* and *new programs on HIC* (FAZIA-technology, new 4pi, …)
- Physics at *RAON*
  - *Sub-Fermi energy* regime starting earlier (>2024): submit ideas to study
  - High density EoS studies will come later

Equation of state studies with HIC: IE/RE

- *Overview talk by Bill Lynch: status and perspectives*
  - Lots has been done but we need more – especially in the high density regime (role of FRIB/FRIB400) → stressed also by K. Agarwal about CBM program
- *Talks from HADES*
  - Very nice data (systematics, high statistics) on E spectra, Flow, stopping, HBT, strangeness production, …
  - Flow analyses: very nice results on v1, v2, v3, v4…
    - Relation v2/v4 to study ideal fluid scaling → Hydro at SIS energies
    - Scaling of v2 and v4: mass number and nucleon coalescence, geometry scaling/Centrality
    - Model comparisons to proton data (JAM, UrQMD, GiBUU): different models work at different regions of centrality
    - Event-wise flow fluctuations
  - Attempts to compare to FOPI data:
    - agreement on protons but disagreement on pion emission

Equation of state studies with HIC: IE/RE

- *Perspectives from HADES Au+Au energy scan at 0.8, 0.6, 0.4 and 0.2 A GeV planned in 2024*
  - new observables and systematic comparison to previous measurements
    - System-Size and Energy-dependence
    - New ideas on flow analyses?
  - HADES @SIS100 important for beam energies below 4 A GeV
  - Efforts in models important
- *Directed and elliptic flow observations in Sn+Sn collisions at Spirit TPC*
  - Spirit collaboration at RIKEN: analysis of flow for p, d, t, 3He and 4He
  - effects of the momentum dependent potential, mass dependence, effects of Coulomb repulsion → comparisons to AMD and attempts to link to Esym and mom-dep potentials

The equation of state of symmetric nuclear matter from heavy-ion collisions (A. Sorensen)

- *The importance of flow measurements face to the future facilities (FRIBI, FRIB400, FAIR…) and experiments like CBM, HADES, others*
- Relativistic vector density functional (VDF) model (SMASH, UrQMD)
  - Issues with describing BES data at STAR and E895
  - Importance of momentum-dependent mean fields
  - Applications to flow: proton flow not enough
- Key questions:
  - What needs to be done to consistently describe flow of most abundant species?
  - How to assign error due to model dependencies?

Extracting the high-density symmetry energy with pion and subthreshold hyperon production in heavy-ion collisions (Zhao-Qing Feng)

- Transport approach for symmetry energy (Lanzhou QMD)
  - Isospin physics at intermediate energies
  - In-medium properties of hadrons in dense nuclear matter
  - Nuclear cluster and hypernuclear cluster production
  - Hadron induced reactions

- Key question
  - relation of cluster formation in heavy-ion collisions and pasta structure in neutron stars?

About IE: INDRA-VAMOS, INDRA-FAZIA, CSHINE

- *New recipes for impact parameter determination*: thanks to the high INDRA capabilities and Bayesian analyses of multiple collective observables (Q. Fable)
- *Isospin diffusion and drift*: rho-dependence of Esym from model comparisons (AMD mostly, but others too…) (C. Ciampi)
  - INDRA-VAMOS (Ca+Ca): 4pi + magnetic spectrometer – direct detection of the QP residue with VAMOS (Q. Fable)
  - INDRA-FAZIA (Ni+Ni): 4pi + new generation PS array + beam energy dependence (timescales!) (C. Ciampi)
    - QP decay: binary and ternary → isospin diffusion, QP fission (statistical and dynamical) → comparisons to transport models (AMD)
- *CSHINE*: Compact Spectrometer for Heavy IoN Experiments (Yijie Wang)
  - Important perspective for future investigations
  - Emission chronology from two-particle correlations → n-rich particles emitted earlier (Ar+Au at 30 AMeV)
  - Ping-pang emission mechanism (coincidence of LP ratios and IMF) (Kr+Pb at 25 AMeV) → Esym effects in ImQMD

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- Key questions
  - Significant strategies with models to compare to data collected at GANIL (TMEP?)
  - What can we learn from QP breakup channel?

Future facilities and experiments

- *FAZIA and INDRA-FAZIA* (G. Casini) – new generation charged particle array
  - Relevance of FAZIA-Tech beyond FAZIA (beam mon., spectator physics, neutrons?)
  - Relevance of neck/spectators from 50 to 400 AMeV + clusters in dilute matter
- The *RAON* facility (Byungsik Hong)
  - Low energy investigations will be possible earlier
- *HIRFL-CSR* external target experiment (CEE) (Z. Xiao): from **p** (<2.8 GeV) to **U** (<500 AMeV) – detect light particles, pions, Kaons, …
  - New Observables important for density and beyond EoS in transport models?
- The Future of *EoS studies at FRIB/FRIB400*
  - New TPC for p, n, pions, etc. at FRIB and FRIB400
- The *Asy-EoS-II* challenge (P. Russotto) at GSI
  - Need for thinking about global strategies
- The CBM experiment @ SIS-100 and BES@STAR (K. Agarwal)
  - v1, hypernuclei, −Σ/+Σ (primordial pions), caloric curves with dilepton obs.
  - Need for theroretical efforts to extract underlying physics

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