Theoretical Perspectives:

Status of UK Nuclear theory

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Outline:

- UK theory effort
- Research grants update
- Current interests
  - Reactions
  - Structure
  - Interface with particle physics
- Challenges for future

Is there a crisis in UK nuclear theory?????

Community has been shrinking steadily over the years.

Only two groups remain: Surrey and Manchester

- Surrey: Tostevin, Thompson, Al-Khalili, Stevenson, Oi (AF), Johnson, Zhao(AF)
- Manchester: Bishop, Walet, Birse, McGovern

(Surrey has had more success with recent grants)

What are the current concerns?

- Apart from Surrey and Manchester, no sign of any new nuclear theory appointments elsewhere
- Danger that such a small number of theorists will spread themselves too thinly to cover too wide an area
- Too often experimentalists happy to use standard codes (OXBASH, Antoine, FRESCO) and don't feel need for guidance from theorists
- A number of theorists still feel they can work in isolation from experimentalists. Many seem content to continue in same area indefinitely and wonder why not getting funded
- I am only theorist here!!

Recent EPSRC grant success has been on joint proposals with UK experimentalists:

1. *Decay studies of exotic heavy nuclei with RISING@GSI*
   Tostevin and Stevenson, with Surrey experimentalists]

   Structure theory: Skyrme mean field calculations to explore the region around ^{170}Dy to study deformation, collective excitations and dynamical symmetries
   Reaction theory: fragmentation reaction mechanisms for two-nucleon knockout of use in spectroscopic studies of neutron rich nuclei (of use in populating isomeric states in heavy neutron rich nuclei via one and two proton knockout)

2. *Probing limits of nuclear existence of heavy proton rich nuclei*
   [Al-Khalili and Stevenson, with Daresbury/Liverpool]

   Structure theory: Beyond mean field calculations for proton rich nuclei near intersection of N=82, Z=82 shell closures. Pairing correlations (proton anti-halo effect) . Residual interaction near the dripline and coupling to continuum.
   Decay studies: effects of continuum on spontaneous proton emission

Current research topics (I)

Nuclear structure:

- Properties of giant resonances and links with nuclear matter equations of state - consequences in neutron star/supernova modelling (funded)
- Studies of isomeric states in heavy nuclei (funded)
- Asymptotic Normalisation Coefficients of mirror states and implications in astrophysics (funded)
- Four-body hypersphericals for ^{10}C, ^{10}B, ^{16}O - supports study of exotic molecules by the Charissa collaboration (EPSRC grant submitted)
- Halo studies: eg ^{11}Li models (new mass measurement data, charge radius, quadropole moment, beta decay)
- *ab initio* structure calculations:
  - "hyperspherical harmonics method" (Surrey, grant proposal being submitted)
  - "coupled cluster methods" (Manchester, funded)
  - "no-core shell model" and links with other methods (Surrey / Manchester)

Current research topics (II)

Nuclear reactions

- Glauber methods for fragmentation reactions beyond spectator core model - to study one and two nucleon knockout, Coulomb breakup, inelastic scattering etc.
- Transfer reaction for nuclear astrophysics - using coupled channels methods
- Impulse inelastic excitations of halo nuclei
- Few-body coupled channels (CDCC) calculations:
  - with rotational excitations inside projectile and
  - extend from 3- to 4-body reaction models
- Proton knockout (p,2p) studies of interest to GSI and theoretical models that go beyond DWBA
- Photonuclear reactions and meson photoproduction

Current research topics (III)

Interface with high energy physics

- Studies of baryon resonances within quark models
- Effective Field Theory (EFT) methods for light nuclei and links with ab initio methods such as no-core shell model. Possible application of EFT methods to study halo nuclei
- Further applications of Chiral Perturbation Theory and other nuclear EFTs to EM interactions with nucleons, 2- and 3-nucleon forces, and properties of few-nucleon systems (EPSRC grant submitted by Manchester)
- QCD phase transition at finite baryon density, linking to lattice QCD approaches, possible collaborations with UK lattice QCD community
- Theoretical studies of heavy-quark and heavy-light mesons, particularly charmonium and D-mesons since these will be produced at PANDA;

New possibilities, ideas in pipeline:

- e-A collider physics: model independent methods for extracting charge densities of exotic nuclei from (e,e). Also (e,e'), (e,e'p)

- Polarization studies

  The first polarization measurement with an unstable beam reported last year (H.Sakai) from RIKEN.

  Theoretical predictions of analyzing powers in nucleon knock-out experiments seem to be sensitive to the reaction theory used.

- Use of EFT to study structure and reactions of halo nuclei

Coordination of UK theory activity

- Seeing limited overlap of interests between Surrey and Manchester groups (effective field theories, hadron physics, *ab initio* structure methods for light nuclei)
- Clearly, theorists cannot survive in current climate without strong links with UK experimentalists
- A number of European theory networks are now springing up;
  - NUSTAR theory (FAIR/GSI)
  - EURONS theory network
  - EURISOL theory network

Current attempt to bring European theory activity together under one umbrella (NTnet) with website (www.nucleartheory.net) to register interest. Currently >160 registered and 2-day workshop on “challenges ahead” planned for early 2006 in Trento.