Status Chapter 4
Hadron-Hadron-Interactions

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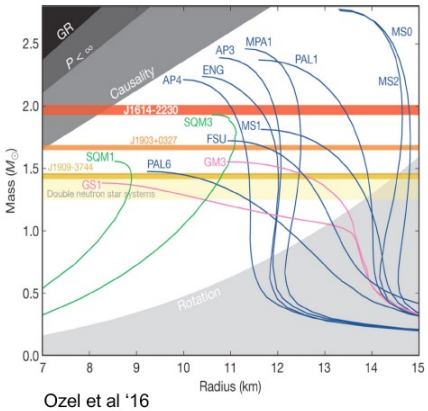
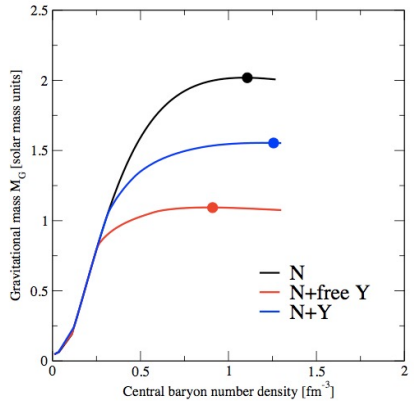
Motivation

- Poor knowledge on many hadron-hadron interactions (e.g. nucleon-hyperon, hyperon-hyperon)

- High relevance for understanding of neutron stars ("Hyperon puzzle")
  - Constraints on EoS from observation of $M_{NS} \approx 2\,M_{\odot}$
  - Hyperons should appear when density increases
    $\Longrightarrow$ EOS softens with hyperon matter and $2\,M_{\odot}$ cannot be reached
  - Repulsive YN and YY interactions $\Longrightarrow$ stiffer EOS
  - Importance of 3-body forces between Ys



Ozel et al '16



Outline

- Theory: hadron-hadron interactions in non-perturbative regime
  - Effective field theories (EFT)
  - Chiral perturbation theory (CHPT)
  - Dyson Schwinger equations (DSE)
  - Dispersion theory
  - Lattice QCD

Outline

- Experiment: hadron-hadron interactions in non-perturbative regime
  - Direct scattering: easy for pp, neutrons accessible via pd,
    p-hyperon only via secondaries (generally difficult, no small rel. mom., low count rates),
    ππ-interaction from pion beams
    No access to πD or hyperon-hyperon
  - Hypernuclei: hyperon-nucleon and hyperon-hyperon low momentum interactions
  - Production reactions: extraction of scattering parameters from exclusive near-threshold production using dispersion theory (→ Christoph's presentation in HPS seminar)
  - Femtoscopy: extraction of scattering parameters two- and three-particle correlations using higher energy collisions, alternative access to hyperon interactions

Current Structure

4 Hadron-hadron interactions

- 4.1 Meson-meson interactions
- 4.2 Meson-baryon interactions
  - 4.2.1 Baryon spectrum / meson-baryon interactions (MM)
- 4.3 Baryon-baryon interactions
- 4.4 Hypernuclei
- 4.5 Scattering parameters from production reactions
  - 4.5.1 Dispersive analysis of production reactions
  - 4.5.2 Femtoscopy

- Proposed length: ~ 20 pages (currently 6)

Activists

- Convener: CB, C. Hanhart

- Contributors: V. Baru, D. Blaschke, M. Bleicher, B. Doenigus, A. Dubla
E. Epelbaum, J. Haidenbauer, P. Hurck, K. Itahashi,
R. Kaminski, B. Kubis, M. Mai, Y. Morino, A. Nogga,
J.R. Pelaez, C. Rappold, T. Reichert, T. Saito, P. Salabura,
A. Szczurek, L. Tolos, D. Wielanek, H. Zbroszcyk, ...

Status

- 4.2 Meson-baryon interactions
  - Some text and figures on EFT and CHPT
  - Author: M. Mai
  - Needs some final touches

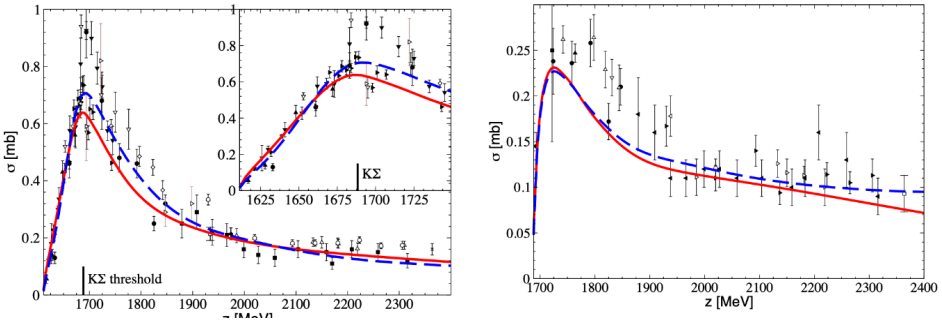


Figure 4: Total cross sections of $\pi^- p \to K^0\Lambda$ (left) and $\pi^- p \to K^0\Sigma^0$ (right). Picture taken from Ref. [**?**].

- 4.4 Hypernuclei
  - First version with review of current experimental status
  - Author: B. Doenigus
  - Accessible states
  - Prospects for hadron beams?
  - Theory contribution needed?
  - WASA@FRS contributions

Status

- 4.5.1 Dispersive analysis of direct production reactions
  - Text in advanced state
  - Author: J. Haidenbauer

- 4.5.2 Femtoscopy
  - Outline of content available (bullet list)
  - Author: H. Zbroszcyk
  - Accessible states
  - Prospects for hadron beams
  - Systematics (source description, resonances, statistics reach)

- TBD: comparison of direct production and femtoscopy

To be done

- Meson-meson:
  - Coupled ππ–KK systems (J.R. Pelaez, B. Kubis)
  - Charm-meson dynamics: π D, K D, ...
- Meson-baryon:
  - Charm-nucleon dynamics: D N, D* N, D_s N, D_s* N (L. Tolos)
  - Other aspects?
- Baryon-baryon:
  - Secondary hyperon-nucleon and antiproton-nucleon interactions (contributors?)
  - Dibaryons and relation to hadron interactions (now moved to Ch. 6) ?
- Further contributions, ideas?