Introduction

- Quantum-statistical BE-HBT correlations as the main source of momentum correlation for identical bosons (with symmetric pair WF’s) in HIC’s
- A toy model simulation, to quantify the effects of an expanding cloud of charged gas on the 2- and 3-particle correlation-functions of correlated pions, is presented

Basics I: Core-Halo model
- Probes for space-time geometry of emitter
- Phase-space density of emitter:
  \[ S(x,p) = S_{core}(x,p) + S_{halo}(x,p) \]
- “core” → primordial hadrons & “halo” → hadrons from decays
- Two-particle correlation fn., with \( q = p_1 - p_2 \):
  \[ C_2(q,K) = 1 + \frac{|S(q,K)|^2}{|S(0,K)|^2} \approx 1 + \frac{\lambda_2 |S_{core}(q,K)|^2}{|S_{core}(0,K)|^2} \]
  - Two-particle correlation strength:
    \[ \lambda_2 = C_2(0) - 1 = f^2 = \left( \frac{N_c \cdot \lambda}{\pi m_c} \right)^2 \]
  - Three-particle correlation strength: \( \lambda_3 = C_3(0) - 1 \)
  - \( \lambda_2 \) & \( \lambda_3 \) → probes for partial coherence

Basics II: Particles’ paths and background
- Particles’ paths modified by surrounding charges → phase shift
- Bose-Einstein correlations contain symmetrised wave functions
- Path of pair: closed loop → Aharonov-Bohm effect with random field
- Background is the internal field → causes the phase-shift

Set-up I: Illustration

- Illustration of 2-particle correlation measurement set-up
- \( a \) and \( b \) as sources, \( A \) and \( B \) as detectors
- \( R \) and \( d \) as distance between the sources and detectors, respectively
- \( k \) as the phase difference and \( L \) as the path length

Set-up III: Random-phase effects
- With random phase:
  \[ \langle |\Psi_r(r_A - r_B)|^2 \rangle \sim 1 + \cos(qR + \phi) \]
  \[ \implies C_{AB} = 1 + \cos(\phi) \]
  - \( C_2(q) = 1 + \cos(qR) \)
  - Phase distribution is Gaussian \( e^{-\phi^2/(2\sigma_t^2)} \)
  - Averaging over \( \phi \) values: \( C_2(q) - 1 = \cos(qR)e^{-2\sigma_t^2} \)
- \( 2 \) - and 3-particle correlation strengths reduced:
  \[ \lambda_2 = C_2(0) - 1 = e^{-2\sigma_t^2} \]
  \[ \lambda_3 = C_3(0) - 1 = 3e^{-2\sigma_t^2} + 2e^{2\sigma_t^2} \]

Results I: \( \sigma_t \) and momentum
- \( \sigma_t = \sigma_t(p) \) close to power-law
- Phase shift: direct dependence on \( N_{\text{charged}} \) and inverse dependence on fireball-radius observed

Results II: \( \lambda_2 \) & \( \lambda_3 \)
- Low-\( m_\ell \) decrease of \( \lambda_{2,3} \)
- Small magnitude, depends on charge density

Model
- \( \phi \) results in a change in the “time-of-flight” \( \Delta t \)
- Charge cloud has \( N_{\text{charged}} \) in a 3-D Hubble flow
- Test particle with initial \( p_{0A} \) in random direction
- Measuring \( t_{TDF}(d) \), calculate \( \Delta t = t_{TDF}(d) - \sqrt{N_{\text{charged}}} \)
- \( \Delta t \) distribution is Gaussian, with width \( \sigma_t \)

Model
- \( \Delta \) related to phase-shift: \( \phi = k \Delta x = \Delta t \cdot v_{x}^2 = \frac{\Delta \epsilon^2}{k\sqrt{m_t^2 + \epsilon^2}} \)
  \[ \sigma_\phi = \frac{\sigma_\epsilon}{k\sqrt{m_t^2 + \epsilon^2}} \]

Summary
- 2- & 3-particle correlations may reveal coherence
- The charge-cloud around a given pair → random background around correlated particles
- Interpreted as an Aharonov-Bohm-like effect
- The \( \lambda_2(m_\ell) \) & \( \lambda_3(m_\ell) \) are modified at lower \( m_\ell \)
- There may be cases where this effect has to be taken into account, esp. at low pair transverse masses

References