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Probe of quantum mechanics through cross section

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Abstract. We mean to emphasize a conceptual ambiguity which lies upon the academic definition of any cross section, in particle physics and quantum mechanics, and which, strictly speaking, might lead to noticeable discrepancies between experimental determinations at highest energies (according to specifications of beams and targets).

Efficient tests of quantum mechanics are thus made obvious.

Let us re-examine the fixed-target case.

For a small interaction probability (otherwise, a differential writing should be in order), cross section is commonly defined as the ratio of the number of interactions per time unit, to the number of incident particles per area unit and per time unit, multiplied by the number of involved targets,

$$\sigma = \frac{N_{inter}/t}{[N_{inc}/(S_x t)] \times N_{targets}}$$

S being a "formal" vicarious macroscopic section area, which may not be specified, but can be ignored since it is blindly cancelled in straight computations, through:

$$N_{targets} = LS\rho N_{Avog}/A$$

(L being the average beam path length, ρ and A the voluminal and atomic masses of the target matter).

What has just been stated might seem forcibly limpid; actually, we have merely contrived a gigantic conjuring trick.

Elimination of the S/S quotient would be meaningful if the S quantity was not logically indefinite if not, even, absurd: since I was unable to link S to any physical (and, thus, logical) specification, I had no right to introduce it from the outset into the calculations. (For instance, it involves an aberrant limit of unitarity.)

This logical artefact (and it is easy to illustrate it) is somewhat analogous to the well-known $0/0$ form being used for unpredictable results. (Ask a computer to valuate the quotient of two indefinite quantities!)

It comes from the illusion that one might experimentally realize a continuous flux of particles (at the macroscopic level, of course), if not a limitless plane wave, and thus avoid the proper quantization problems intrinsically needed for it.

It practice, indeed, fluxes are discrete (even quite scarce, frequently), with no quantum constancy or coherence between a data taking and the following one.

One may retort that all this is only a writing procedure intended to escape a rather heavy formulation as impact parameter integration: regrettably, such a presentation would be void of any physical relevance, at least in the close vicinity of the target (where the most part of the interaction should be concentrated), owing to the quantum uncertainty which lies upon the positions of both particles (perhaps much larger, e.g., than $\sqrt{\sigma} = 10^{-2}$ fermi for $\sigma = 1\,\mu$b).

From another point of view, cross section might become extremely large at the highest energies, making the distance between neighbouring target particles quite significant (just like between incident particles in the case of very dense colliding beams, moreover).

One should therefore face an N-body problem!

Such a circumstance easily attained would make any usual valuations sheerly misleading.

All the same, such a conjecture is not necessary: even if σ remains finite, it has never been established, to my knowledge, in any theoretical physics, that the interaction does not include, at least at highest energies, a component of "far-distance effect" (if not of infinite range, like the coulombian potential).

And indeed, the usual academic definition of σ essentially presupposes a dense group of target particles, and would be absolutely meaningless for a unique isolated target (as fundamentally expected).

The concept of individual cross section seems, therefore, fully mirifical.

1 Conclusion

On the experimental ground, in the new generation measurements, discrepancies might be searched for with various states of beams, as a direct test of classical quantum mechanics.

On the theoretical ground, full quantization of the incident beam (especially for space locations), instead of the classical plane-wave assumption, should be in order, to clarify and disentangle situations.

Indeed, limiting cases are not compatible.

So, through any dense target material, the incident wave will undergo multiple scattering, so that its *transverse quantum extension* should be large relatively to the target particle one.

Conversely, with colliding beams at highest energies, through cooling, transverse quantum extensions should usually be weak and quite similar, symmetrically, for interacting particles.

A similar situation is still expected for internal quantum numbers.

2 Remark

The *longitudinal extension* of the wave pack still raises more uneasy problems, for neutrino oscillations or heavy-quarks oscillations, studied in [1] and [2].

References

1. M. Laloum, How Far Studying $B^0 - \overline{B}^0$ Couplings with Quite Limited Samples, Nuovo Cimento A, **106**, 1159 (1193).
2. M. Laloum, Formalism of Neutrino Oscillations Revisited, preprint 10.2.98, Collège de France, IN2P3 – CNRS.