Particle Poker

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1 Introduction

The game Particle Poker requires not the usual deck of cards, but the special Particle Cards [1], where each card represents an elementary particle. They are all either leptons or quarks, to be more precise, bosons, the force carriers are excluded. The Standard Model, which contains all quarks and leptons (as well as bosons) is depicted on the left of Figure 1. It organizes matter into three families, from which two are included. In addition to that, the **c**, "charm" quark was excluded. It is relatively rare in Nature due to its relatively high mass (same considerations were made when omitting the 3rd family of elementary particles).

In this basic version of the Particle Poker game we intend to map the usual poker combinations to this peculiar set of cards, always keeping in mind the physics behind the symbols. In the advanced version (which is not introduced here) the physical principles are more dominant, fading the similarity to the usual poker.

Most of the combinations follow instinctively from the particle nature of the cards. A good example is the hadron pair, where we just take an existing meson (see on the right of Figure 1). Other seemingly easy combinations, on the other hand, had to be changed more substantially. But before getting into details, the strength of the cards should be clarified.

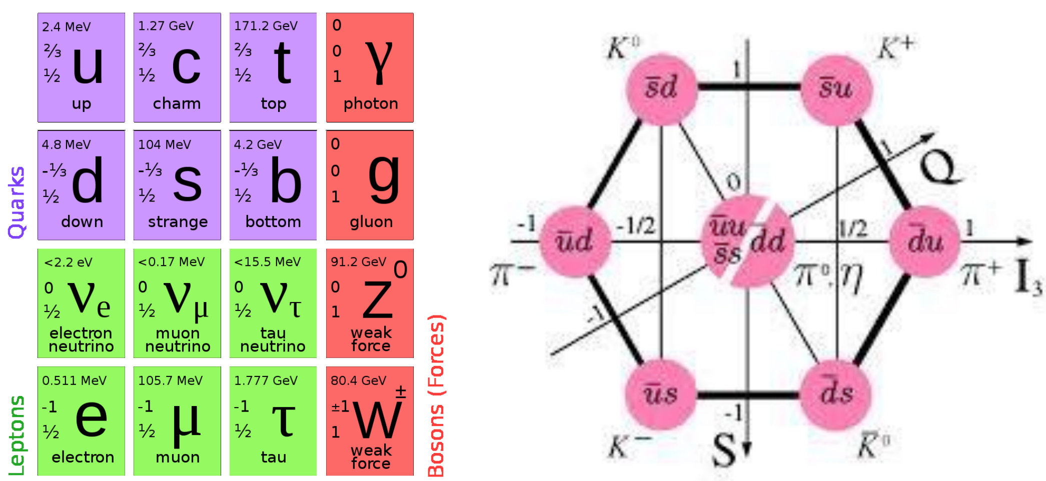

Figure 1. The Standard Model of elementary particles (left) and the meson octet (right)

2 Card strength

The strength of a card is simply its (assumed) mass. This is motivated by the principle that higher mass states are less common in Nature, making that particle more valuable as a card. Figure 2 illustrates the order. Note that leptons and their antiparticles are identical from this point of view, as well as the colors of the quarks, but we differentiate quarks and antiquarks: the latter is always stronger.

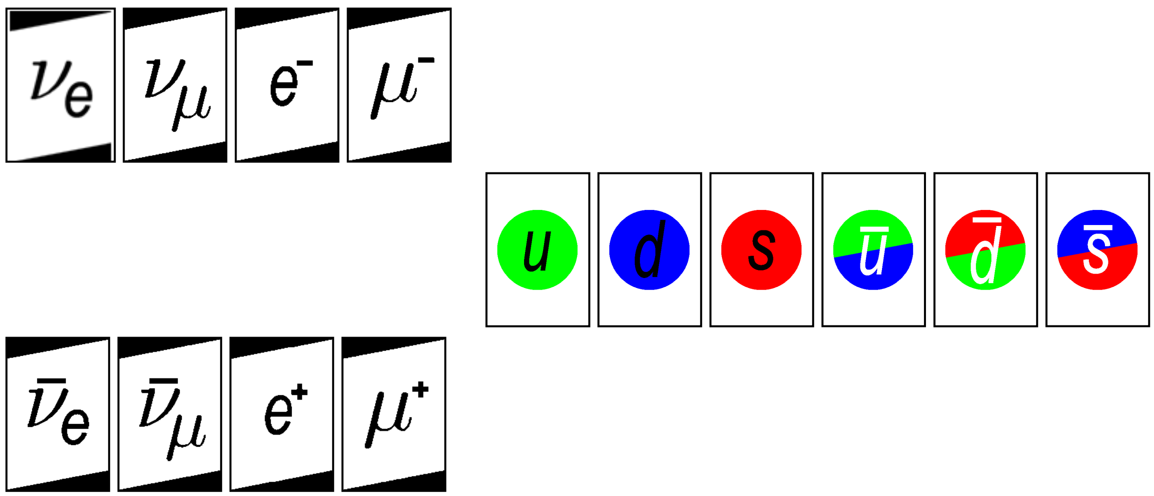

Figure 2. Card strength increases from left to right. Upper and lower row leptons are equally strong

2 Combinations

In this section we detail the combinations defined for Particle Poker, presenting them in increasing order. Table 1 illustrates the similarity between the two poker games, it compares the probabilities of the combinations. Quantitatively they deviate, but follow the same trend, thus we can keep the usual order of combinations (e.g. drill will be always stronger the two pairs, etc.).

Another important difference was necessary to introduce: the lack of colors. Leptons do not have it, observable hadrons are color neutral, thus having e.g. a combination with 5 red quarks did not seem natural. This implies that the combination “flush” is not interpretable and it is missing from this game. We did not want to discard straight flush, however, that being the most valuable combination, but traditionally it is defined as a junction of a straight and a flush. Our workaround definition for that is then to require a straight to consist only of particles, or antiparticles, respectively.

If two people have the same hand, the card strength decides the outcome of the game, comparing first their highest cards, if they agree the second, and so on. Now let's review the defined combinations in detail.

Combination	% [poker]	% [particle poker]
1 pair	42.3	43.3384
2 pairs	4.75	7.2982
Drill	2.11	6.2062
Straight	0.392	3.915
Full House	0.144	1.3926
Poker	0.024	0.6424
Straight flush	0.00139	0.5322
Royal flush	0.000154	0.033

Table 1. Comparing probabilities of the 5-card poker and the Particle Poker

High card. This occurs when we have none of the named combination (we have nothing). In this case the highest card at hand decides the faith of the game, hence the name.

One pair. We distinguish two different sets of pairs, hadron pairs and lepton pairs.

- **Hadron pair** is a valid meson (see right panel Figure 1), e.g. a color neutral combination of a quark and an antiquark.
- **Lepton pair** is a slightly more complicated combination. Like hadron pairs, they consist of a particle and an antiparticle, but we can further divide them into three groups:

    - **Same family, charged**: we require the lepton and the anti-lepton to be in the same family and the pair to carry electric charge.
      These are the following combinations: $(e^-, \overline{\nu_e})$, (e^+, ν_e), $(\mu^-, \overline{\nu_\mu})$, (μ^+, ν_μ).
    - **Same family, neutral**: in this case the lepton and the anti-lepton also come from the same family, but the pair should be electrically neutral. The following combinations fulfill this requirement: (e^-, e^+), (μ^-, μ^+), $(\nu_e, \overline{\nu_e})$, $(\nu_\mu, \overline{\nu_\mu})$
    - **Different family, neutral**: the lepton and the anti-lepton come from different family, and the formed pair is not charged. This yields: (e^-, μ^+), (e^+, μ^-).

Two pairs. We can either have two hadron pairs, a hadron pair plus a lepton pair, or the least valuable one, two lepton pairs.

Drill. It would seem natural to define the drill as any hadron (e.g. a color neutral combination of 3 quarks, or 3 antiquarks), but this definition would yield more drills than two pairs. To keep the combination order similar to poker's, we had to limit the drill definition to only those hadrons, which are formed of three different quarks. So this is a color neutral combination of the u, d, s (or $\overline{u}, \overline{d}, \overline{s}$) set.

Straight. We can freely construct a straight combining the lower and upper rows of the Figure 3, we do not differentiate between particles and anti-particles, not even in the hadronic sector. We can also go circular, continuing our straight with ν_e after the s quark. The color of the quarks is also irrelevant. An example for a straight is: ($\mu^+, u, d, \overline{s}, \nu_e$).

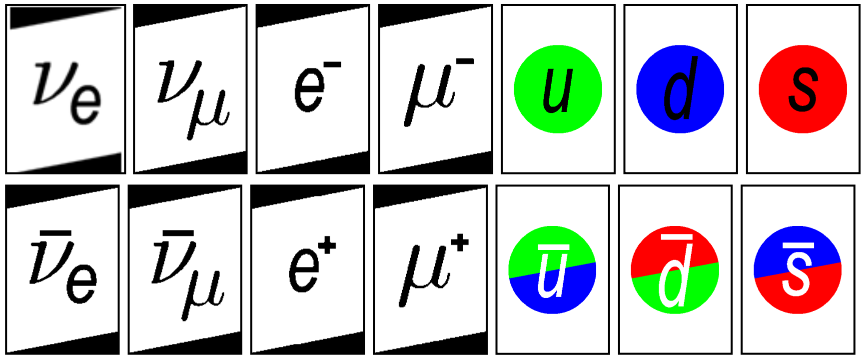

Figure 3. Straight strength

Full House. This is traditionally a combination of a drill and a pair. Here, as for the drill part, we accept any hadron (not just the ones with different quark content) and only a lepton pair.

Poker. Similarly to its origin, the poker combination is defined as four of a kind, with the addition that the particle number must be zero. For the lepton poker this leaves us the following combinations: (e^-, e^+, e^-, e^+), $(\mu^-, \mu^+, \mu^-, \mu^+)$, $(\nu_e, \overline{\nu_e}, \nu_e, \overline{\nu_e})$, $(\nu_\mu, \overline{\nu_\mu}, \nu_\mu, \overline{\nu_\mu})$.
In the hadronic sector we further require the pairs to be color-neutral.

Straight flush. This is a straight where the constituents are either particles or antiparticles, respectively. (So upper and lower rows of Figure 3 are not interchangeable this time.)

Royal flush. As in the usual poker, this is the greatest straight flush, in this case it is: $(e^+, \mu^+, \bar{u}, \bar{d}, \bar{s})$.

2 Closure

In this basic version the gameplay is the same as in the usual poker, for that please refer to any online tutorial. All poker variants (5 card, Texas Hold'em, Omaha) can be played with the rules defined in this article, although Texas Hold'em and Omaha were not yet investigated in detail.

An advanced version will be introduced in another article. There the goal was not to map the poker combinations to the Particle Cards, but to invent a new, more physics-motivated game, which therefore resembles poker. In that version the gameplay also incorporates more aspects of the physicists' daily life, e.g. refilling empty chips with grant-applications, and so on.

References

[1] Judit Csörgő, Csaba Török, Tamás Csörgő: Card Games with Particles