THE GREAT CELEBRITY RECEPTION: HIGGS SIMULATION
FOR THE TEACHER

DESCRIPTION
In an effort to make the classic Higgs mechanism party analogy more interactive, this simulation is set up for 20-40 students. This is also a great opportunity to develop student understanding of inertia. Teachers could introduce the party cartoon before the doing the simulation before this activity, but I believe after is better.

STANDARDS
National Science Education Standards (U.S. National Research Council)

- Physical Science Content Standard B:
  As a result of the activities . . . students should develop an understanding of:
  - Motion and forces.
  - Interactions of energy and matter.

LEARNING OUTCOMES
- Describe mass in terms of the relative acceleration of an object.
- Describe the root origin of mass in terms of a Higgs field interaction.

Essential Knowledge: Mass is a consequence of an object interacting with its surroundings.

BACKGROUND MATERIAL
This activity will help students build an understanding of how particles can interact with the "Higgs field."

Links and URLs:
Higgs cartoon - http://www.coimbra.lip.pt/atlas/higgsmec.htm
Higgs video "Journey to Discover the Nature of Mass,"
http://cms.web.cern.ch/cms/Media/Videos/Films/index.html

IMPLEMENTATION
Student groups need:

1 30-cm ruler
1 Meter stick
1 2-meter stick or equivalent
1 Deck of regular playing cards
1 Classroom without desks

Preparation

- Remove the face cards of all but one suit. There will only be one King, Queen and Jack available for selection.
- Each student takes a playing card from the deck.
- After all students have one card, set aside any remaining student cards. Be sure the three face cards have been distributed.

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The Party
Students move about the room for about one minute (a la musical chairs). Discourage them from lumping with their friends. Music helps the activity; a good example is *It's Not Unusual* by Tom Jones. When the music stops, the students stand in place. Announce the three face cards, as follows: the Jack is designated as an electron; the Queen is a muon and receives a ruler; the King is top quark and receives a meter stick.

The students with the face cards slowly spin in place. The electron does so with one arm extended. The muon holds the ruler from an extended arm, and the top quark holds out the meter stick. The remaining students represent the interaction with the Higgs field. Any students within the reach of a particle must now form a tight group around the particle student. Students should see that particles with larger masses make bigger groups. This illustrates the basic coupling to the Higgs field.

The activity can be adjusted to suit different numbers of students or room sizes. In an extreme case, a student with a 2-meter stick or equivalent can simulate a very large mass.

Inertia
To drive home the concept of inertia, have all the students not in one of the three groups move to one wall of the room as observers. Place the three clumps of students near the middle of the room, maintaining the tightness of the group. Next, have the three student particles face the teacher, and all students coupled to the particles face away from the teacher. Only the student particles should be able to see the teacher. Without speaking, the teacher then points in a direction and each student particle begins to move in that direction without speaking. The associated clump of students should remain close to their particle during the motion. The teacher should change the direction 3-5 times.

Observers will quickly see that larger clumps (more inertia) are harder to accelerate or stop while the smaller clumps (less inertia) are easier. If time and technology permits, the teacher can film the exercise with a digital camera and break down the acceleration of the clumps with frame-by-frame analysis or Logger Pro.

ASSESSMENT
Individual teachers will create their own assessment plans to check learning outcomes.

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BACKGROUND

Science books often refer to the relationship between mass and weight. The books will sometimes make reference to the nebulous phrase, "amount of stuff." The concept of mass (or inertia) is far better understood in conjunction with acceleration.

During the activity your teacher will direct your motions around the room. It is important that you move freely for the first phase. Real particles don't have friends and don't need to clump with their buddies. In the second phase, you will move in groups, but remember that real particles can't anticipate where they would need to go next.

POST-ACTIVITY REFLECTION

1) How was the size of each group determined?
2) What was the general relationship between the size of the group and its rate of change of direction?
3) How does the change in motion reflect each student particle's interaction with its surrounding group?
4) What quantity do these "groupings" represent and how do the groups compare with each other in terms of this quantity?

Extension Activity:
If Logger Pro or video analysis is available, find the relationship between this quantity and the reach of each particle. Use this to predict the number of students influenced by a reach of 4 meters.

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