Lead or Follow? I swing both ways!

Swing Dancers are Masters of Physics: Tension and its Magic on the Dance Floor

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"I'm a physicist, but I'm also a swing dancer," exclaims Krister Shalm, a quantum physicist who has earned the nickname of the "dancing physicist" by using swing dancing to explain complex ideas like tension in physics ("TEDxWaterloo"). From swing outs to tuck-turns and to free-spins, Lindy Hoppers have become masters of physics.

Between the 140th and 141st streets on Lenox Avenue, New York's Harlem opened the doors to the Savoy Ballroom in 1926, which produced some of the era's most popular dances including the Flying Charleston, the Big Apple, the Lindy Hop, and more ("The Savoy"). Also known as the "world's finest ballroom," the Savoy was a popular dance venue from the 1920's through the 1950's and played a vital role in the nurturing of Lindy Hop and jazz music. From dancers like Frankie Manning and Norma Miller, the legacy of swing dancing lives on today not only thrives throughout dance communities across America and the world but also within the scientific community.

Krister Shalm, also known as the "dancing physicist," is a quantum physicist at the Institute for Quantum Computing at the University of Waterloo in Ontario, Canada (Shalm). He specializes his research in discovering and expanding quantum mechanics' new applications for everyday use especially in technology and can relate his work in the laboratory to swing dancing. Some of these applications include the use of photon "entanglement" in cyber security and high-speed powerful computers to solve complex problems that regular computers cannot.

Through his research, Shalm has studied "a type of partner dance that happens at the quantum level" by separating the smallest parts of light, called photons, and entangling them together to become partners in "the strongest connection that physics allows," which is stronger than an individual photon particle ("TEDxWaterloo'). Twentieth century physicist Albert Einstein called this connection "Spooky-action at a distance" because during entanglement, the two photon particles will remain correlated even if they are two physically separated particles. "Spooky-action at a distance" relates to swing dancing because of the powerful connection created by the tension between the two partners.

Krister Shalm states that "this partnered connection," is a fundamental component of swing dancing. He explains that the energy that is produced through the connection of tension provides the ability to social dance and break the rules of a choreographed routine so "that I could go to almost any city in the world, not know the language, and yet find someone that I could share an experience through dance with" ("TEDxWaterloo").

In a partner dance, such as Lindy Hop, the connection between the two partners is the physical communication through tension exerted by the "lead," typically the male partner, and returned by the "follow," typically the female partner; the force yields to an equal and opposite value. This tension allows for improvisation on the dance floor and adding variations to basic moves during social dances.

Daniel O'Conner, a senior member of the Saint Vincent College Swing Dance Club acknowledges Krister Shalm's work and shares his own experiences from his three years of leading: "Tension serves a few purposes for me. The most important part of tension is the ability to redirect my partner. If they are moving one way, tension allows me to help them change speed or direction. Tension also allows me to convey my pulse[1] to my partner. Essentially, if I'm pulsing with the music and I have strong tension, my partner can feel my pulse through the tension in the connection. We stay on rhythm together. If I change speeds or footwork patterns, my partner feels it in the connection" (O'Conner).

Sherrie Tucker, professor of musicology and jazz studies from the University of Kansas, validates O'Conner's statement as she writes in her 2013 published paper, "Swing: From Time to Torque (Dance Floor Democracy at the Hollywood Canteen)", about how the forces produced between the lead and the follow permit improvisation (Tucker). More specifically, she explores how "partners could do markedly different steps–even ones unknown to and unanticipated by one's partner–as long as the basic rhythm was preserved" (Tucker).

[1] "In music and music theory, the pulse consists of beats in a (repeating) of identical yet distinct periodic short-duration stimuli perceived as points in time[1] occurring at the mensural level" (Winold).

Lindy Hop "breaks away" from most partner dances like the waltz and the foxtrot where the footwork is generally identical, leaving little room for stylization from either partner. On the other hand, the pulse and the tension produced in swing dancing allow room for creativity between the partners. Regardless, stylization in the partnered dance is still possible while one dancer (the lead) will guide the movements of the other dancer (the follow) by non-verbally signaling changes in movements through body language and changes in tension.

Lindy Hopper, a name used to call dancers of the Lindy Hop, and dance instructor from the University of York, Andy Connelly, draws connections between the force of tension in social dancing and Newton's laws of motion in his article titled "The Science and Magic of Lindy Hop." (Connelly).

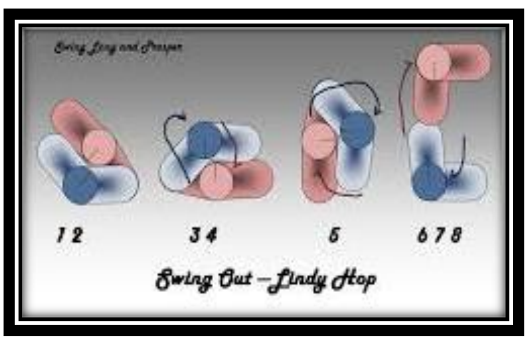

Figure 1

Newton's first law of motion states that "an object remains at rest, or in uniform motion in a straight line, unless it is compelled to change by an externally imposed force" (Griffith). A swing out, a fundamental 8-count Lindy Hop move, pictured in Figure 1, is an example of Newton's First Law of Motion.

After counts 7 and 8, the follow (pink) is standing apart from the lead (blue), waiting for the lead's tension of pulling the follow in on counts 1 and 2. This is the "change by an external force" caused by the lead taking a step backwards on the left foot as shown in Figure 2. Counts 1 and 2 picture the lead bringing the follow to a closed position towards the lead. As stated in

Figure 2

Newton's law, the follow will move in "uniform motion in a straight line" on counts 1 and 2, and the follow's momentum does not change until "catched" by the arm of the lead at the end of count 2 as the follow will feel the momentum to continue to move past the lead.

When applied to swing dance, Newton's first law of motion helps Lindy Hoppers to understand the basic fundamentals of swing outs. More specifically, this understanding of the tensions produced in swing outs increases the follow's awareness of exerting an equal amount of force when the lead pulls the follow in on counts 1 and 2. A common mistake that beginner follows make is not matching the tension that the lead produces. The follow will step into the lead too early (before the lead exerts any force) due to anticipation and visual cues or the follows will "run" into the lead and not follow the natural tension produced with the backwards rock-step of the lead.

Another Lindy Hopper from Saint Vincent College's Swing Dance Club commented on the importance of tension during swing outs. Hannah Wheeler, sophomore, discusses swing outs and tension's impact from a follow's perspective. "The tension between the lead's hand and the follow's hand is important in timing during a swing out. When the lead pulls back, the follow then knows to come back in from the swing out [on counts 1 and 2]. If there was no tension, then the follow would not know what to do after the swing out and when to come back in" (Wheeler).

Proceeding to Newton's third law of motion, it states that "if object A exerts a force on object B, object B exerts a force on object A that is equal in magnitude but opposite in direction to the force exerted on B" (Griffith). An experienced follow will match the tension of a lead. When the lead starts to change the magnitude of the tension, this signals to the follow that a new dance move will be performed. Andy Connelly mentions in his article that “these equal and opposite forces, in accordance with Newton's third law of motion, allow the follow to dance in synchrony with the lead: as a mirror image” (Connelly). This symmetry of the dance partners remains unbroken unless the “pairs of forces become unbalanced” where for example, the lead will signal to the follow by increasing or reducing the tension and the pair can smoothly transition into the next move as the follow again matches the tension of the lead (Connelly).

MIT graduate student and international swing dance performer, Sommer Gentry, has also studied how Newton’s third law relates to swing dancing (“MIT student”). She has combined her hobby as a swing dancer with her career of research in engineering, psychology, and human motor-control studies to construct robots for rehabilitation or sports training while proving with her investigations that the tension in partner connection, likewise argued by the “dancing physicist,” Krister Shalm, is a core component of swing dancing.

Moreover, the changes in tension from the pulls and pushes through the dancer’s hands creates a smooth transition between tuck turns and swing outs, according to Gentry, is the “highly evolved system of communication and control via haptic (touch-based) signaling” that permits a follow to be guided by the lead without visual cues and relying only on the tension that is produced between the dancing partners (“MIT student”).

To verify the validity of her pure haptic signaling theory in swing dancing, Gentry blindfolded follows and asked them to dance with their partner. As expected from Gentry, the follows were remarkably able to dance with their leads without any visual cues. The experiment proved that “even without visual information, an experienced follower can correctly interpret the lead's haptic signal (e.g., a push on the hand) by executing that signal's corresponding move (e.g., a half-spin)" and emphasizes the effectiveness of strong tension in swing dancing ("MIT student").

During an interview, Gentry described another experiment that she conducted on the topic of musicality that contributes to her findings on tension (Gentry). Experienced leads and follows were unknowingly given headphone sets with different songs; the beat of the leads' and the follows' matched, but with different emphasis on the beats. While the leads reported that they believed that both partners danced to the same song, the follows acknowledged that they recognized that the songs were different. This concludes that the partners carried the same pulse throughout the dance, despite the unmatched emphasis on beats, and the partner connection produced overcame the dissimilarity in beat emphasis for the follow. Therefore, the follow was able to be guided by the lead without the lead recognizing the difference. This experiment provides insight into the powerful relationship that swing dancing produces in regards to strong tension and partner connection.

Lindy Hopper O'Conner commented on Gentry's study on what occurs if the strong tension is broken between the two partners: "With weak tension, I've noticed that my partner relies on vision to follow my dance moves. Because of this, my partner will be slower than the beat and we will not sync up properly. Weak tension also makes it harder to perform quick dance moves. Tension can provide spring or energy to make a spin or other move faster. Without this [strong tension/partner connection], dancing to fast tempo songs becomes relatively impossible (unless you sacrifice form and rhythm)" (O'Conner).

In addition, O’Conner highlights that understanding physics is very beneficial for swing dancers because it helps the dancers to improve their technique, and it’s critical “if you want to best communicate with a partner on the dance floor” (O’Conner).

Rising in the late 1920’s from the Harlem of New York, swing dancing has attracted both dancers and physics scholars to investigate the physics of partner dancing. In particular, the beauty of the partner connection and the importance of strong tension in swing dancing are exposed by Krister Shalm and Sommer Gentry who have interconnected their love for swing dancing and their professional careers as physicists and mathematicians to explore this field. While Shalm compared the strength of partner connection and the significance of tension to quantum physics and entangled photon particles, Sommer has organized experiments that prove the effectiveness of haptic communication. Without the knowledge of tension, the beauty of swing dancing could not be described because “when dance scholars talk about swing...we enter a world of physics” (Tucker).

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