Affine Bruhat order, Kazhdan-Lusztig combinatorial invariance, and spooky dualities

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Abstract： I will present experimental discoveries on the Bruhat order of affine Weyl groups, revealing surprisingly rigid combinatorial structure. In joint work with Libedinsky and Villegas, we show that all Bruhat intervals in A2 tilde are determined by a simple convex-geometric construction. More strongly, we give a complete classification of dominant intervals: two intervals are poset-isomorphic if and only if their associated polygons are congruent, producing a striking equivalence between Euclidean geometry and the combinatorics of affine Bruhat intervals. Our results imply invariance of Kazhdan–Lusztig polynomials for these intervals and suggest that the long-standing Lusztig–Dyer combinatorial invariance conjecture might hold for unexpectedly simple reasons. For the intervals we classify—and, we conjecture, for all affine Weyl groups—every nontrivial isomorphism between Bruhat intervals arises from a composition of global symmetries, finite Weyl group actions, and piecewise translations. Finally, I will describe a "spooky" phenomenon: certain intervals turn out to be isomorphic to the dual of others, sharing the same R-polynomial, suggesting the action of a non-existent "phantom" longest element in affine Weyl groups.

Gaston Burrull is a mathematician working in representation theory and algebraic combinatorics. He is currently a Postdoctoral Fellow at the **Beijing International Center for Mathematical Research (Peking University)** and previously held a postdoctoral position at the **Einstein Institute of Mathematics** at the **Hebrew University of Jerusalem** under Professor David Kazhdan. He received his Ph.D. in 2023 from the **University of Sydney**, where he worked with Professor Geordie Williamson on the thesis *"On the combinatorics of parabolic Schubert varieties."* His research focuses on modular representation theory, Coxeter groups, and Kazhdan–Lusztig theory. His work includes introducing the **p-Jones–Wenzl idempotents** in *Advances in Mathematics* (with Libedinsky and Sentinelli) and a publication in *International Mathematics Research Notices* on the **Combinatorial Invariance Conjecture** for affine **SL3** (with Libedinsky and Plaza). He has presented his results at institutions such as **BIT**, the **Technion**, and **MATRIX**, and has served as a referee for *Advances in Mathematics* and the *Canadian Journal of Mathematics*.