A Physicist's Guide to Texas Hold 'Em

What are the odds that poker can be explained by statistical physics, much the same as a variety of other complex systems? They're pretty good, according to physicist Clément Sire of Université of Toulouse and CNRS in France, who demonstrates in a recent paper that many of the statistical properties of poker tournaments are universal. Sire's model makes connections between poker and evolution, extreme value statistics and the physical model of persistence.

"In this Letter, we study a very human and futile activity: poker tournaments," Sire writes in his paper, submitted to an APS Physical Review journal. His model quantifies the evolution of Texas hold 'em tournaments, based on aspects such as the distribution of chips, the number of surviving players over time, etc. Overall, his results closely mirror those observed in real-life online tournaments.

"While human laws (such as bluff, prudence and aggressiveness) determine much of the individual outcomes of poker tournaments, these tournaments are ideal for statistical analysis because they are isolated systems—they don't depend on outside factors," Sire explained to *PhysOrg.com*.

While Sire's model provides an accurate description of poker tournaments, the model also shares similar characteristics with other seemingly unrelated areas. For example, the physical model of persistence tells the probability that some random process never falls below a certain level. Or, in poker talk, the persistence model describes the number of surviving players (those that have not lost all their chips).

As Sire explains, the "decay rate" of players (as they lose their chips) is exactly the same as the (exponential) growth rate of the blind bets, which are bets that start off the pot of money at the beginning of every game and are therefore also the minimal bets.

This also means that the growth rate of the blind bets entirely controls the pace of a tournament, which in practice allows the organizers of a tournament to control its duration. The model shows that the total duration of a tournament grows only logarithmically (i.e. very slowly) with the initial number of players, which explains why the wide range of real tournament sizes (100-10,000 players) remains manageable.

"The model can also help poker players to evaluate their current ranking in a poker tournament," Sire said. "For instance, if a player owns twice the average stack, he is currently in the top 90%. If his holding is only half of the average stack, he only precedes 25% of the other players.

"Consider a temporal random signal [such as the graph of a company's stock]. Its persistence is the probability that it never goes below (or above) a given threshold," Sire explains. "With my colleague Satya Majumdar, we have devised several ways to compute this quantity in various contexts, which decays exponentially fast, or as a power-law. Persistence has been measured in many physical systems, and has obvious applications outside physics: for example, what is the probability that Google's stock remains above $450 for the next year (certainly high, I admit)?"

Other connections involve biological evolution. Due to the competitive nature of the game, Sire found similarities with evolutionary models dealing with competing agents. Also, when analyzing the statistical properties of the chip leader (player with the most chips at a given time), Sire found the same phenomenon that occurs in the "leader problem" in evolutionary models. Namely, the average number of chip leaders grows logarithmically (i.e. very slowly) with the number of competing agents, or total number of players.

"Physicists are currently studying models of competing agents," Sire explained. "Possible applications exist in the field of econophysics: markets, options theory in finance, decision making, rumor propagation, etc. Another application I've been involved in is evolutionary biology. One devises simplified models of the creation or extinction of species (or new genes). With my colleagues, we have shown that the number of preeminent 'species' generically grow with the total number of species, and that this result should hold in many contexts (for instance, the number of leaders of the Fortune 500)."

A third connection involves extreme value statistics, a physics branch that analyzes the probability of the occurrence of extreme events. In Sire's model, some of the properties of the chip leader also display extreme value statistics: the probability that the chip leader holds a given stack is universal (and given by the well-known Gumbel distribution in physics.)

"Let us consider a random signal: for example, the stock of IBM, or the daily temperature in New York," Sire explains. "Now let us look at its maximum in a one-month period. This is itself a random variable. If the initial random signal is only weakly correlated in time, the probability distribution of the (monthly) maximum of the signal takes a universal form which is independent of the precise nature of the considered signal! Recently, physicists have been interested in the maximum of strongly correlated variables, which can now take any form."

As for finding the best strategies, Sire's model doesn't determine optimal playing decisions, other than general hints from observations, For example, the advice that "a player should be careful when playing bad hands if many players have already bet" is totally irrelevant, according to the model, as far as the global evolution of the tournament is concerned. However, the model predicts that there exists an optimal probability to go all-in (to bet all one's chips).

Sire notes that two famous mathematicians (e.g. Emile Borel and John von Neumann) have looked for optimal strategies in head-to-head poker, but prediction for tables with ten players including all-in events still presents a formidable task.

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For more information, see Clément Sire's Web page: http://www.lpt.ups-tlse.fr/clement