Symmetrical Chess
www.symmetryperfect.com/shots

A mathematically-sound introduction to the universe of chess variants!

Axiom system
developer- Greg Schmidt
http://games.groups.yahoo.com/group/axiom-system

Spherical Chess 324

The featured, chess-related game was first invented and implemented in December, 2008 and last revised in December, 2016 by Derek Nalls.

A customized version of the Axiom program was written to play this game although unfortunately, not well due to its extreme branching factor. It is absolutely free, fully-functional and available for download.

It is a 2-player, perfect-information game classified as an elimination game generally and a royal queens game specifically. It is a spherical-surface, 3-D game yet it can be represented, viewed and played via any/all of 2 available opening setups using a 2-D gameboard with 2-D pieces.

There are NOT 2 variants.
There is only one game.

Each of the seemingly-different, 2 available opening setups in 2-D are merely different perspectives of exactly the same 3-D game. Use whichever one(s) you can think most clearly in geometrically while playing white or black.

Due to perfect, geometrical symmetries existing only at the start of the game by N-S, E-W, NE-SW, NW-SE axes of reference for the 2-D gameboard, its 8 available directions of movement and all 2-D pieces, there are also 8 ways to transpose any game played within each of the 2 2-D representations of this game- 16 total.

Games of this class can be studied mathematically under combinatorial game theory and to a limited extent, under plane geometry.

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goals and purposes

I have always believed that out of an infinite number of possible, playable chess variants that could be invented, a single, best, perfect game existed in the imaginary-yet-real, theoretical realm of perfection, waiting to be discovered. Of course, it would never permit itself to be discovered via semi-random searching.

At some point within the last 19 years, I ascertained that this "holy grail" game should be definable with certainty, by indirect means, thru the categorical exclusion of all other imperfect design features, by correctly applying a sufficiently high number of important quality criteria.

I was hopeful that a large set of correctly-defined, important quality criteria relevant to chess variants would eventually emerge which would allow no more than one game to be invented, in sharp contradiction to my established reputation as one of the most prolific chess variant inventors- quickly designing large numbers of games anew in full compliance with <u>every</u> given, quality criterion I could discover anew.

In the midst of these creative and exciting yet frustrating times, my efforts, experience, inspirations and imagination toward inventing new games seemed impossible to defeat. I even wondered once or twice if I would burn-out. Fortunately, the unexpected final series of important, paradigmatic, theoretical breakthroughs occurred.

My chess variant collection has consisted of 20-50 ever-changing games in response to an ever-increasingly long list of quality criteria since shortly after I began in 2000. Now, only one featured game remains … Spherical Chess 324. It deserves more than a casual examination since it is possibly the only perfect, 3-D chess variant in existence.

I would classify myself as a moderate amongst inventors of chess variants- neither an unimaginative conservative clinging to familiar, standard Chess nor a radical embracing all types of crazy gameplay unwisely and uncritically. Moderation should not necessarily be automatically associated with blandness, however. An optimum balance of highly-desirable game features at their apex exists, unique to this game, which was extremely difficult to attain- requiring appr. 19 years of work (with a couple of long interludes) to reach its maturity or ultimate refinement.

Of the game designers who adequately recognize, understand and respect such theoretics, the majority accepts or believes that many desirable game features exist or work intransigently at cross-purposes. Indeed, these inverse relations (that can easily be discovered by anyone experimenting with game designs) possess a mathematical logic that seems to be inescapably true at a cursory glance.

Yet with an incisive understanding of combinatorial game theory (as applied and advanced to a new, formally ill-defined or undefined area of chess variant design), most of the stale or unsavory compromises can be overcome or avoided while an optimum balance can be achieved.

The featured game is fast and dangerous yet extremely deep theoretically and almost perfectly stable. The featured game is easy to start playing and enjoyable yet very hard to master.

Of course, the featured game is symmetrical in every important, measurable way attainable for 2-player, 3-D chess variants.

The featured game, by being an elimination game of the royal queens class (with <u>all</u> 2-D pieces other than queens being capable of promotion to queens), is within one of very few classes of chess variants with the theoretical potential to be perfectly designed.

Quality chess variants can only be created in accordance with ALL knowable, valid, important theoretical design principles available to the present day ... only IF the knowledge and tools available to the present day are adequate.

My assessment is that they are definitely adequate today and probably, today's standards or definitions of game quality will always remain adequate. However, until only several years ago, adequate knowledge and tools certainly did not exist. Incidentally, the odds against creating a high-quality chess variant by chance involve combinatorically-high values.

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blueprints for incredibly bad inventions

Overall, the literature of chess variants demonstrates a random scattering of 1000's of the infinite possible, stable [not in every case!] arrangements of gameboards, pieces, rules, etc. Despite the constructive intentions, hard work and abstraction by their various chess variant inventors, statistically it is as if the population as a whole which created this class of games did so with no guidance of intelligent design. Virtually all of these games could have instead been randomly generated by a computer program designed to intentionally create chaotic, messy chess variants. This is the fate of all work undertaken without correctly applying the most important game-design principles.

Unfortunately, the vast majority of the numerous, new chess variants have NOT improved in non-trivial ways in recent years. The bad examples of ancient and/or popular gameworks worldwide continue to inspire, misguide and be used to disastrous ends.

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the supreme importance of symmetry

The importance and preferability of symmetry is generally under-estimated or completely dismissed today by most "schools of thought" in the chess variant world.

Essentially, the situation is that most "schools of thought" are failing to think much since they have complacently allowed themselves to remain disgracefully uneducated to some important, modern areas in mathematics, geometry and combinatorial game theory which are relevant and moreover, vital to what they do. Their arrogant lack of respect, comprehension and even interest in the key ramifications of modern mathematics (in particular) and the scientific method (in general) is shocking.

They have failed to definitively break free from the stagnant, primitive paradigms of tradition, ego and worship (which notably requires little rigorous work). Perhaps, their failure is rooted in thinking of their endeavor purely as artistic instead of scientific (as it has the potential to be).

With chess variants, mathematics is much more than an assortment of tools for subserviently measuring the incidental characteristics of the art of arbitrarily-designed gameworks. Instead, mathematical game-design principles, correctly applied, determined the amount of substance or quality or science within the art (if you prefer) of the gameworks themselves.

Using mathematics a bit does not insure that one's endeavor is scientific, though. Understanding mathematics as well merely makes one capable of attaining scientific standards … with the unavoidable investment of huge amounts of rigorous work (presuming that the need to do so is humbly accepted). Even then, if <u>any</u> wrong decisions are made at any of several critical junctures where value judgments over mathematical game-design criteria are required and unavoidable, then the quality of the final creative product will be marginal at best.

ALL games that are NOT symmetrical (including Chess) are NOT worth playing-chaos & abstract junk. They should be totally ignored or disregarded for being nothing more than failed or flawed attempts to create a decent, high-quality game.

The main reason is that asymmetry adversely impacts many other critically-important game design factors such as structure, function, stability, fairness, balance and equality- all of which, by definition, are related to symmetry (which encompasses many manifestations of invariance besides geometrical symmetry). Conversely, I am wary of all types of asymmetry since some are already generally known and/or proven to be destabilizing to games.

By deep and abstract ramification theories, asymmetries always introduce instabilities into a system [Note: A chess variant can be defined mathematically along such lines.] that will manifest themselves with effect. Therefore, all detectable asymmetries should be avoided at all costs in every aspect of game design.

Strict Rule- Any asymmetrical game is an imperfect game.

[Note- This rule does not at all imply that any symmetrical game is guaranteed to be a perfect game. Several other important quality criteria besides symmetry must also be in place to have a chance to invent a virtually perfect game.]

Unfortunately, appr. 90% of the chess variants published upon popular web sites are asymmetrical (with respect to their gameboards and/or opening setups) and as such, immediately fall into this "total waste of time" category.

Out of the balance of appr. 10% symmetrical chess variants, virtually all are badly designed or imperfect- flawed in one or more important way. This hardline view (misinterpreted as radical by those who fail to recognize its mathematical foundations) is what inspired me to become a diligent game designer in the first place. I wanted to do something constructive right which I could clearly see that most others were-are doing wrong.

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the hazards of careless invention

People who do not understand chemistry should not brew explosives, despite the temptations. Chess variants involve some important mathematical principles approachable from various viewpoints such as combinatorial game theory, AI (computer science), set theory, statistics, probability, vectors, geometry (symmetry), logic at levels of design, playtesting and analysis, etc … which will almost surely be messed-up by any game inventor with an inadequate or absent comprehension.

[Notwithstanding, chess variants are predominantly, practically dealt with best directly in their own terms and discussed by established conventions.]

The relativistic view that a universe of personal preferences are at work, where anything uneducated game designers and uneducated game players agree to liking must be equally good, denies the fact that sound, provable, scientific criteria for game quality comparison exist in theory or can be created.

Although inventing games can be regarded as a creative endeavor or process and it is an admissible possibility that the finest goal is to cause fun, excitement, mental stimulation for the human player(s), whenever mathematical criteria are available to make determinations regarding desirable game characteristics, it is imperative that they be used instead of discarded. This will not detract from the "finest goal" at all.

Make no mistake. You are walking into a thick mathematical jungle when you presume to have the authority to invent as many as <u>ONE</u> chess variant for the rest of the world to play. [In fact, most chess variant inventors have minimal knowledge even of chess variants. So, they should NOT have ever published any of their works.] If you ignore <u>any</u> of the known or knowable "signposts of quality", then you are likely to get lost. Arrogant imaginings to the contrary will, in fact, change nothing.

Thereafter, you will probably create "nothing but abstract junk" which will someday- perhaps soon- be identified correctly as "nothing but abstract junk". Then, your legacy will be ridiculed and rightfully so for distracting and annoying serious players and game inventors via "your voluminous, incoherent messes". That could not be anyone's goal for the sake of the work they are undertaking.

Unfortunately, these desperately-needed "signposts of quality" are mostly unknown at present to formal, combinatorial game theory. Besides, branches of mathematics concentrate strictly upon measurement- not value judgments … even those important enough to make quality evident to intelligent people. Hence, one must invest much of their own time creating original work thru theorizing, playtesting, experimenting with game designs ... to attain and refine game-design principles which one has compelling reasons, based upon game-theoretical geometric and combinatoric truths, to believe are valid or optimum. This considerate labor-of-love has the practical effect of rewarding willing players of new games with a good experience for their efforts.

Some people foolishly believe inventing great games is as simple and sure as running down pedestrians with a fast car. [No need to look back, either.]
In actuality, the tremendous complexity innate to chess variants renders this naïve view false to the extreme.

Unfortunately, nearly every new game of hasty origin is poorly conceived.
This contributes to "bad game pollution" which is already a severe problem and destined to reach a highly-disruptive level within 10-20 years for serious players in search of quality games.

One must work very hard to invent quality games. Most people, who for reasons I will never understand, wildly imagine that they have a neat game to give to the world, fail to do the latter (if not also the former). Ironically, although playing quality games should be fun, inventing, implementing, playtesting, refining quality games is definitely not all fun. It is rigorously hard work that can send a developing game thru many versions over years of experimentation and learning. Fortunately, the creative process is theoretically interesting and successful achievements are satisfying.

Only those who appreciate and understand mathematics and geometry with earned competence (formal and/or informal) are in a position to craft chess variants that fully unleash the power of their vast possibilities. After all, they are combinatoric, dynamic, mathematical machines operating within a finite, closed geometric universe by nature or definition.

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the satisfactions of thoughtful invention

The mathematical nature of the universe of chess variants is ever-intriguing. I approached this subject as a 2-D or 3-D geometrician. I experimented with a great many interesting geometric patterns, angles, arrangements for gameboards & pieces, suitable for creating unique, quite-playable games, while I restricted myself to using only sliding pieces of unlimited range. After all, I only allowed a couple of special moves (conversion and portal travel) that I found to be play-enhancing to be used within the featured game. I critically examined a large number of other special moves possible in detail and found them to be play-degrading and/or destabilizing (in ironic contrast to their inventors' intent).

I always imagined that the BEST possible arrangement(s) of gameboards and pieces suited for creating games that are thrilling to play is limited- probably definable to only one perfect or best game. I always strictly used an increasingly-long list of quality criteria to try to keep the number of my creations as low as possible. Accordingly, only one, possibly-perfect game currently exists in my catalog despite my continuing efforts to invent more games and variants.

The "unlimited freedom I allow myself to restrict" defines my unique style and protects the quality (by my effort to establish and enforce standards mathematically).

move-intensive vs. rule-intensive games

Chess variants are geometric games at heart, consistent with what is visually evident, and I have firmly ascertained that this is the best "expression of the art" available creatively. Notwithstanding, chess variant designers hold the power to build their games to function anywhere along a wide range between purely move-intensive (visual, geometric) and purely rule-intensive (non-visual, arbitrary, quasi-legal). Some make a poor choice at this critical juncture.

Rules should not be highly-complex for chess variants.

[Yes, this is a rule.]

In playtesting, I have found that games with highly-complex rules, no matter how conceived, always degrade instead of enhance the level of play (e.g., excitement, danger, theoretical depth) readily or potentially available within the competitive arrangement of the pieces on the gameboard. Furthermore, it gives the players headaches just trying to keep the rules straight to be sure they make legal moves instead of focusing mainly upon plotting their next move tactically and strategically (which is where the enjoyment within a game lies).

Rules of simple-moderate complexity can be implemented by talented AI programmers where many consequent advantages for the universality of one's games materialize. Over the coming years, it is probable to become legend that any chess variants without a custom-written program might as well not exist.

Of course, some chess variants with highly-complex rules exist. [Many do not have custom-written programs. Some may eventually with great effort.] Unfortunately, they are always awkward, tedious and unenjoyable games that compel one to wonder what the constructive purpose for their invention could have been in the first place except to torment all of its players.

To be sure, the featured game is move-intensive to the maximum extent possible and rule-intensive to the minimum extent possible.

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the ideal number of players

Typically, 1-player chess variants are merely geometric puzzles classifiable as trivial (i.e., solvable) games. Their complexity must be limited to what is reasonably solvable by intelligent people (of less than genius level) often thru trial-and-error learning methods to hold adequate purpose, incentive or enjoyment for the general game-playing public. Unfortunately, once solved, then they can be solved in exactly the same way any number of times. When a game becomes totally predictable, it not only is no longer fun [It is pointless.] to continue to play.

Having numerous, graduated skill levels can keep a 1-player game interesting and challenging for a while longer but inevitably, either thru success at the highest skill level or total frustration at an intermediate skill level, their human player naturally loses interest within a short time. The educational lessons imparted by games of this class may have lasting value, nonetheless. Otherwise, their theoretical depth is insignificant compared to chess variants with 2 or more players. Furthermore, 1-player games must be asymmetrical and they cannot accommodate any opponents, human or computer (obviously).

Games with 3 or more players always play-out in a manner, by accident and/or design, which unfairly distributes advantages and disadvantages, large and small, to every player in the game. It is not possible to perfectly stabilize a game with 3 or more players against this complex effect given force by the cumulative activities of every player. Furthermore, no individual player holds adequate power, being outnumbered by players each of equal power, to prevent this complex effect from having great impact upon one's self (and every other player) within every game played.

The intolerable problem with this situation is that it becomes quite possible for a player other than the one who has played best to actually win some games and for a player who has played best to actually lose some games.

Only in games with exactly 2 players is this complex effect reduced to zero as each individual player holds equal power with only one opponent in the game and has exactly half-control of the game. Moreover, the player who has played best is guaranteed to win the game.

In summary, 2-player chess variants can be vastly, theoretically deep, symmetrical, fair and they can accommodate opponents, human or computer (obviously).

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the best possible 2-D gameboard

Chess variants have the amazing distinction of being amongst the most complicated games known (by combinatoric measure) which are classifiable as perfect-information games. With the exact location of all types of 2-D pieces on the 2-D gameboard defined physically to certain spaces, all 2-D pieces play-out with visual, geometrical clarity. The 2-D gameboard is essentially a geometric playground or finite universe of small, manageable size within which the pieces can be played in an extremely vast (although finite) variety of ways.

The featured, spherical-surface, 3-D game can be represented upon a flat 2-D gameboard which, with the 2-D pieces for each of the 2 players set to their most symmetrical opening positions, maintains perfect quadrilateral, geometrical symmetry via 4 axes- 2 orthogonal axes (vertical and horizontal) and 2 diagonal axes.

Games built upon 2-D gameboards constructed of spaces can be accomplished best using regular polygons that can be replicated without creating unused gaps of space (or requiring more than one type of polygons to prevent unused gaps of space). This leaves only spaces with 3 sides (triangles), 4 sides (squares) or 6 sides (hexagons) that meet the primary criterion for tessellation.

The main drawback to constructing 2-D gameboards out of tessellating equilateral/equiangular triangles is that their orientation alternates. This renders linear moves visually confusing and complex to plot and follow from their origin to their destination. This leaves only spaces with 4 sides (squares) or 6 sides (hexagons) that meet the secondary criterion for tessellation due to their constant orientation.

The maximum number of geometrically-contiguous directions of linear movement available for 2-D pieces upon square-spaced, 2-D gameboards is 8 and upon hexagonal-spaced, 2-D gameboards is 6.

With fewer directions of movement available for hex-spaced, 2-D gameboards than square-spaced, 2-D gameboards, there is no comparative advantage to designing hex-spaced games instead of square-spaced games unless for the novelty. So, I have created no games based upon hex-spaced, 2-D gameboards nor do I ever intend to.

Square-spaced, 2-D gameboards are unique compared to hex-spaced, 2-D gameboards due to 6 of their 8 45° angles being unfamiliar to hex-spaced, 2-D gameboards.

Hex-spaced, 2-D gameboards are unique compared to square-spaced, 2-D gameboards due to 4 of their 6 60° angles being unfamiliar to square-spaced, 2-D gameboards.

Consequently, the featured game is based upon an ideal square-spaced, 2-D gameboard which maintains 4 axes of symmetry. This made it ideally suitable for extension to a spherical-surface, 3-D game by allowing unrestricted, continuous space movements in all 8 directions available upon every square-space with the flat 2-D gameboard (from what would otherwise be edge spaces).

Due to it being a spherical-surface 3-D game, 324 square-spaces at 18 W x 18 H were required which also gives a square shape overall (in appearance) to the 2-D gameboard. No fewer than 324 square-spaces can accommodate the needed number of players' 2-D pieces and neutral 2-D pieces in the proper arrangement at the start of the game. I can attest to the fact that the number of square-spaces is not too high to retain human playability.

As a game-design principle, the higher the number of square-spaces for the 2-D gameboard, the better in terms of stability, theoretical depth and fairness. Each square-space is displayed at 32 x 32 pixels with the centered pieces displayed at 25 x 25 pixels. Accordingly, a monitor and video card capable of attaining a resolution somewhat greater than 576 x 576 pixels (e.g., 1024 W x 768 H pixels) is indispensable to fully display the featured game running within the Axiom program.

The unusual representation of the flat 2-D gameboard is ideally suited to tracing linear moves in all 8 directions, esp. those that traverse between its apparent yet illusionary edges. Wherever an intersection of 4 lines occurs (i.e., the orthogonal red lines and diagonal dark blue lines intersect or the orthogonal red lines and diagonal light blue lines intersect) denotes the center of square spaces that pieces can occupy. This looks strikingly different from (and better than) the convention of just boxing all of the pieces inside a square space without marking its center or indicating where linear moves in the 8 available directions from and to it would extend.

You may be surprised to find that I did all I could to minimize the number of square-spaces required for the 2-D gameboard. However, spherical-surface, 3-D games necessarily must have far more 2-D spaces, on average, than 2-D games to preserve stability.

Portal travel occurs orthogonally (vertically N-S and horizontally E-W) and diagonally (NE-SW & NW-SE). This means that all 8 directions of movement are available from EVERY square-space out of 324 total including those that give the illusion in 2-D of being edges (which can offer only 5 directions of movement) and corners (which can offer only 3 directions of movement).

Consequently, on this omni-directional, continuous space, flat 2-D gameboard, the bishop has equal movement capabilities to the rook. Both the bishop and the rook can potentially reach exactly 19 other square-spaces with a move from anywhere upon the flat, 2-D gameboard.

[Note: This is merely a hypothetical illustration of a principle since it is impossible for the bishop to actually exist within this game.]

Orthogonal movements across portals rarely cause confusion for people to trace as they circumnavigate the flat 2-D gameboard since they always follow a single line.

Diagonal movements across portals sometimes cause confusion for people to trace as they circumnavigate the flat 2-D gameboard since they always follow a double line (except in the special case of perpendicular bisectors where they follow a single line).

Moving strictly in 8 directions in 2-D across the surface of the Earth (an imperfect sphere), via a ship on the ocean or a vehicle on land, is a reasonably good, real-world analogy to playing this game.

The game actually is a sphere where only the surface is available for play.
Since no movement by depth into the sphere is allowed, 18 out of the 26 directions of movement available to cubic, 3-D games are unavailable to this game.
With only 8 directions of movement available to this game, it is the same as in a square, 2-D game in this respect.

If you prefer, then you may construct a physical, 3-D model of this game upon the surface of a sphere. Comparatively, the sphere carries the handicap that you can only see a maximum of half of the spaces from any perspective with progressively more of those that are visible at progressively distorted angles as your view moves from the center to the limb.

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the best possible 2-D pieces

Sliding 2-D pieces of unlimited range (i.e., "sliders") are the only type of moving 2-D pieces used in the featured game because they can potentially utilize every geometrically-contiguous, 2-D gameboard space in their given directions of movement. By the way, sliding 2-D pieces of limited range (i.e., "steppers") are undesirable because they unnecessarily slow down the game and make it tactically tedious as they comparatively, severely reduce move options.

Essentially, leaping 2-D pieces (i.e., "leapers") are out-of-tune and ill-fitted to their geometric environment as they waste or miss spaces and usually move at odd angles to geometrically-contiguous, available 2-D gameboard spaces.

Due to it being a spherical-surface 3-D game, 48 2-D pieces per player are required at the start of the game to insure minimal, defensive stability (where mainly sliding 2-D pieces of unlimited range are used) esp. since attacks against royal 2-D pieces can come from any of 8 directions. I can attest to the fact that the number of 2-D pieces per player is not too high to retain human playability. As a game-design principle, the higher the number of 2-D pieces per player, the better in terms of stability, theoretical depth and fairness.

You may be surprised to find that I did all I could to minimize the number of 2-D pieces per player required at the start of the game. However, spherical-surface, 3-D games necessarily must have far more 2-D pieces per player, on average, than 2-D games.

For our purposes, the movements of the 2-D pieces can only be regarded as symmetrical with reference to 4 axes- the 2 orthogonal axes (vertical and horizontal) and the 2 diagonal axes. A symmetrical slider is invariant under transformations in its movements with respect to 4 axes that can be cut across the 2-D board orthogonally or diagonally. Likewise, an asymmetrical slider is <u>not</u> invariant under transformations in its movement with respect to 4 axes that can be cut across the 2-D board orthogonally or diagonally.

There are 12 unique, major sliding 2-D pieces used/usable with 4, 5, 6, 7 or 8 directions of movement upon the square-spaced, flat 2-D gameboard in the featured game. Of these 2-D pieces, 2 are "symmetrical sliders" and 10 are "asymmetrical sliders". Of these 2-D pieces, 1 is a 4-directional slider, 4 are 5-directional sliders, 2 are 6-directional sliders, 4 are 7-directional sliders and 1 is an 8-directional slider. They all have in common that they possess the orthogonal movements of a rook as a minimum.

Some 2-D pieces do not start the featured game on the 2-D gameboard yet can potentially be brought into play via the promotion of 2-D pieces that do.

The 2-D symbols used to represent all sliding 2-D pieces are visually indicative of the choice of directions in which they are capable of moving in 2-D.
Their geometric, straight-line 1-D move chosen is as a ray visually clear, direct and as sensible as a beam of light.

The 2 symmetrical sliders are already familiar to anyone who has ever played Chess. Of these 2-D pieces, 1 is 4-directional; 1 is 8-directional.
They are the rook (4-directional: orthogonal) and the royal queen (8-directional: diagonal & orthogonal).

The 10 asymmetrical sliders are unfamiliar to nearly everyone. Of these 2-D pieces, 4 are 5-directional, 2 are 6-directional and 4 are 7-directional.

"Blocks", incapable of movement, are neutral 2-D pieces that either player can capture by replacement. Starting the featured game as buffer 2-D pieces that surround both armies, an abundance of blocks (68) strongly influence the entire game by deterring the relentless capturing of valuable 2-D pieces by both players from the 8 angles of attack that are often open in this continuous-space game. They equally provide a removable defensive protection as well as a removable offensive limitation to the players whose pieces they surround.

Buffer 2-D pieces are employed to prevent both players from being able to capture any opponent's 2-D piece using their first available double-moves thereby dominating the tempo of the opening game.

Only a minority of the 68 blocks that start the game upon the flat 2-D gameboard ever get captured by either player during the course of a typical game.
Absolutely no more buffer pieces than necessary are desirable since this would pointlessly render the game uneventful, slow and tedious. Absolutely no less buffer pieces than necessary can be tolerated by any means since this would catastrophically render the game unstable to the advantage of one of the players.

Each player needs to choose appropriately at times during the game whether it is more important to leave them in place to deter offensive moves against him/her or capture them to open angles for offensive moves against his/her opponent.

The only 4-directional slider used (the rook) is symmetrical. It has 4 directions of movement- all orthogonal.

It can be half-promoted into a choice of 4 5-directional sliders at the cost of 2 moves, single-promoted into a choice of 2 6-directional sliders (diagon rooks) at the cost of 3 moves or double-promoted into the 8-directional slider (the royal queen) at the cost of 4 moves.

All 4 5-directional sliders used are asymmetrical. Since they are transitional 2-D pieces attained only by half-promotion from a rook, they are not formally, individually named. They all have 4 directions of orthogonal movement plus 1 direction of diagonal movement.

In turn, they can be half-promoted into their appropriate 1 out of 2, evolutionary 6-directional sliders (diagon rooks) at the cost of 2 moves.

Both of the 2 6-directional sliders (diagon rooks) used are asymmetrical.
They both have 4 directions of orthogonal movement plus 2 opposite directions of diagonal movement. The diagon rook I has 4 directions of orthogonal movement plus NW-SE diagonal movement. The diagon rook II has 4 directions of orthogonal movement plus NE-SW diagonal movement.

In turn, they can be half-promoted into a choice of 2 appropriate, evolutionary 7-directional sliders at the cost of 2 moves or single-promoted into the 8-directional slider (the royal queen) at the cost of 3 moves.

All 4 7-directional sliders used are asymmetrical. Since they are transitional 2-D pieces attained only by half-promotion from a diagon rook (I or II), they are not formally, individually named. They all have 4 directions of orthogonal movement plus 3 directions of diagonal movement.

In turn, they can be half-promoted into the 8-directional slider (the royal queen) at the cost of 2 moves.

The only 8-directional slider used (the royal queen) is symmetrical.
It has 4 directions of orthogonal movement plus 4 directions of diagonal movement. The queens are the royal 2-D piece in the game with the sole game-winning objective being to capture all belonging to your opponent. All other 2-D pieces belonging to both players can potentially be promoted into royal queens, though.

Spherical Chess 324
piece set
http://www.symmetryperfect.com/shots/pieces

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material values of the 2-D pieces

To further assist players, the material values of the sliding 2-D pieces have been calculated manually and are included for the featured game. To be sure, relative 2-D piece values (a weighted, holistic estimate of positional and material values) are automatically generated by various computer chess programs and can sometimes be accessed by players. These complex estimates are typically inaccurate, though, to the limits of the strength of play of the program used. Consequently, I still regard the relatively-simple calculation of material values as a useful, clarifying reference.

The complex method of reliably estimating the portion of material value attributable to the royal 2-D pieces (queens), the practical royal value, is included. The promotion potential of all of the other 2-D pieces to queens subtracts greatly from the ideal royal value to attain it. This completes the landscape of material values of all 2-D pieces used in Spherical Chess 324.

The number of royal queens remaining upon the 2-D gameboard, both by absolute measure and relative to one's opponent, are important considerations as well with the practical royal value of the material value of each remaining, royal queen increasing as the number of royal queens is decreasing. In this manner, the practical royal value of the material value of the set of royal queens remains constant regardless of the number of elements it contains. Obviously, if the number of royal queens remaining reaches only one, then it has a supremely-high, practical royal value of its material value.

Tactical richness is provided by an adequate range of 3 distinct material values of 2-D pieces starting the game on the 2-D gameboard [Note: As the game progresses, 5 distinct material values of 2-D pieces are likely to emerge via promotion.] with a distribution such that generally, the most valuable 2-D pieces are the least numerous and vice versa. Moreover, the most valuable 2-D pieces are progressively farthest from the front lines, best protected and initially accessible from fewest angles with the royal queens being the extreme case.

Spherical Chess 324
opening setup (text)
http://www.symmetryperfect.com/shots/texts/setup.pdf

Spherical Chess 324
2 opening setups (graphic)

White Halved N-S | Black Halved E-W
http://www.symmetryperfect.com/shots/setup/setup-1.html

Black Halved N-S | White Halved E-W
http://www.symmetryperfect.com/shots/setup/setup-2.html

An essay describing a potentially universal method for estimating the material values of relative 2-D piece values within chess variants (by the restrictive, proper definition) of any given design is included elsewhere.

universal calculation of piece values
http://www.symmetryperfect.com/shots/texts/calc.pdf

Spherical Chess 324
material values of pieces
http://www.symmetryperfect.com/shots/texts/values-spherical.pdf

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2-D gameboard defines 2-D pieces and 2-D pieces define 2-D gameboard

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A remarkable reality of game design is that where sliding 2-D pieces are used exclusively for both players, the best, unique opening setup for a given board game is always precisely, tightly definable. In contrast to nearly all chess variants invented by others, the chosen opening setup in the featured game is NOT determined arbitrarily (i.e., as one of many mediocre, adequate possibilities) or thru hopefully-intelligent guesswork. If either were the case, the yielded result would almost surely be less than ideal.

Furthermore, from the exact 2-D gameboard design, it can be determined exactly which sliding 2-D pieces are used, in exactly what numbers and their exact opening setup.

The principle is elegantly simple. Nonetheless, the exact 2-D gameboard design required for a game or variant is not known at the beginning of the invention process. Its determination entails a complex, interdependent process wherein the 2-D gameboard design must be adjusted and tested to accommodate the needed sliding 2-D pieces appropriately arranged to meet all offensive and defensive requirements while the mystery of which and how many sliding 2-D pieces are needed is dictated by the 2-D gameboard design.

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the best method of capture

There are a few prevalent and several little-known methods of capture used in various chess variants. A survey has held me to the conclusion that “capture by replacement” is the most directly intuitive as well as geometrically clear, allowing tactics to be formulated quickly and easily thru a point-to-point visualization.

On a related topic of interest, “capture from a distance” is not allowed because it is equivalent to a special case, double-move where “capture by replacement” occurs upon the first move of the double-move and the return to the original space occurs upon the second move of the double-move yet it only counts as a single-move. This excessive, offensive power would probably be destabilizing.

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minimizing the first-move-of-the-game advantage

The first-move-of-the-game advantage (by white) is generally the greatest enemy to perfect fairness, balance, equality, stability, etc common to ALL decently designed, turn-based chess variants. Everything that can be done to minimize it should be done (short of making draws commonplace). Nothing unnecessary that increases it should ever be done.

Game stability is maximized where there exists perfect balance.

Of course, it is always recommended that an even number of games be played where each player is fairly assigned white and black an equal number of times. However, if only ONE game (an odd number) is to be played, a fair random method for assigning white and black should be used (such as a coin flip).

This does not at all alter the fact that it remains vitally important that even if only ONE game is to be played, it must be as fair as possible to the player who unluckily lost the coin flip. Even an isolated, single incident of bad luck that would surely equalize over many events must have as close as possible to absolutely zero bearing upon a game of pure skill [void of any element of chance].

A minimal first-move-of-the-game advantage (by white) is assured due to:

1. **A balanced white-black-black-white move cycle with the consequences that although white gets the very first single move of the game, black gets the first double move of the game.**

2. **The front lines in every direction sealed with neutral buffer 2-D pieces.**

3. **The arrangement of opening positions in which neither player can capture any opponent's 2-D piece in less than 4 moves, trap the most valuable, royal 2-D pieces (which are very well protected) or irrefutably take decisive positional or material (conversional) advantage.**

4. **The use of a minimum of 48 2-D pieces per player at the start of the game.**

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details- the "pendulum move"

For 2-player, turn-based chess variants-

A. **Only turn-orders consisting of an even number of moves allow an equal number of moves per player at the completion of each move cycle. This is imperative for fairness.**

B. **Only turn-orders consisting of a multiple of 4 moves allow the possibility of each player alternatively being ahead and behind by no more than one move an equal number of times at the completion of each move cycle. This is highly desirable for fairness.**

The "pendulum", white-black-black-white, 4-move turn-order is extremely effective in terms of fairness. Moreover, it is expressible in the fewest terms and is easily memorable by the players as "a double-move game beginning with one single-move by white".

After the first move in the turn-order, white is ahead by one move and black is behind by one move.

After the second move in the turn-order, there is zero advantage for white & black.

After the third move in the turn-order, black is ahead by one move and white is behind by one move.

After the fourth move in the turn-order, there is zero advantage for white & black.

Thereafter, the cycle repeats itself.

Note that white and black both have a one-move advantage and a one-move disadvantage once per move cycle.

The "pendulum move" turn-order applies which dictates double-moves alternating between the two players throughout the game except for the very first move which is one single-move by white. It is so-called since a minimum advantage or disadvantage that is never more than one move (maintaining an average of zero moves) swings or alternates fairly and continuously between the 2 players throughout the entire game.

Although this unconventional move cycle was originally adopted to improve game stability, it carries the beneficial side-effect of greatly increasing the theoretical depth (since it is dependent upon the variety of possible ways a player may use the 2 moves comprising his/her turn).

Of course, a double-move can be used on the same 2-D piece twice. This would account for a squaring (exponential increase) of the theoretical depth per turn if not for the fact that it is equalized where a 4-move cycle is applicable (instead of a conventional 2-move cycle).

However, a double-move can also be used on two different 2-D pieces once and for many different purposes- offensive or defensive, material or positional, capturing or non-capturing, conversional (promotional), etc. Hence, an exponential increase of the move options and theoretical depth of an ordinary exponential time complete game (like many chess variants) occurs.

There is (as there must be) absolute equality and perfect quadrilateral symmetry in 3-D between the 2 armies at their opening positions of the featured game. Quadrilateral symmetry is usually destroyed for the rest of the game after the first move (by white) or soon thereafter.

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conversion schemes

The introduction of the various conversional moves for sliders- promotion (half, single, double) at the cost of 2, 3 or 4 moves, respectively, with the number of moves required running proportionally to their desirability, adds a dimension of theoretical depth far beyond what any chess variant reliant strictly upon positional moves can possibly offer.

This is particularly important in the opening game where the variety of possible tenable, offensive and defensive tactics available to both white and black seems to only be limited by the players' imaginations. Furthermore, the stability and fairness of the game is maximized by an opening setup that allows the defending player a vast number of move options (conversional and positional) for adaptably and effectively dealing with any conceivable type of attack.

Nonetheless, the incentives and temptations for launching an attack, assessed to be tenable, are great, esp. if one thinks the likelihood of his/her opponent being clever enough to discover and use precisely the correct tactic required to successfully repel a given attack is remote. So, stagnation or the failure of both sides to attack in the opening game due to mutual fear of overwhelming counter-attacks is as unlikely as it is irrational. In fact, definitively tenable attacks are richly rewarded within the featured game that, although defensively stable, is NOT designed to favor defense over offense.

The existence of potential conversional moves for all 2-D pieces except the royal queens prevents move options from being over-restricted. To the contrary extreme, available move options are actually increased vastly over what would exist if there were only positional moves available.

A meaningless race by both players to promote all 40 of their 2-D pieces into royal queens (those that do not start the game as royal queens) in the opening game, to neither players' advantage, should not occur unless both players are complacent since positional moves by lower-value pieces can be used to attack higher-value pieces more readily. For example, royal queens occupying forward positions can easily be attacked by rooks.

Since all 2-D pieces used within the featured game start with all 4 orthogonal (horizontal & vertical) directions of movement as a given, promotion is all about adding up to 4 of the needed, diagonal directions of movement to all 2-D pieces except the royal queens (obviously).

The details of the uniform promotion scheme for 2-D pieces applying to the featured game need not cause confusion (or even, require memorization) to play reasonably well since the main concept is logically intuitive, direct and accessible.

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1. **Double-promotion requires 4 moves.**

   It is highly evolutionary, adding all 4 new directions of diagonal movement with unlimited range to a rook with 4 pre-existing orthogonal directions of movement. This must yield a royal queen. Note that the 24 rooks per player are the only illegible pieces for double-promotion.

   The intermediate stages are numbered and color-coded as stage 1 (yellow), stage 2 (light purple) and stage 3 (dark purple). A 2-D piece undergoing double-promotion retains the entire movement capabilities of its original piece (a rook) throughout the process.

   This upgrade in power is desirable where urgency is only a small concern.

   double-promotion
   http://www.symmetryperfect.com/shots/promo/promo-2.html

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2. Single-promotion requires 3 moves.

It is moderately evolutionary, adding 2 new, opposite directions of diagonal movement with unlimited range to the pre-existing directions of movement for a 2-D piece. This implicates that either a rook is single-promoted into a diagon rook (I or II) or a diagon rook (I or II) is single-promoted into a royal queen.

A 2-D piece undergoing single-promotion retains the entire movement capabilities of its original piece throughout the process.

The intermediate stages are numbered and color-coded as stage 1 (yellow) and stage 2 (light purple).

This upgrade in power is desirable where urgency is only a moderate concern.

single-promotion
http://www.symmetryperfect.com/shots/promo/promo-1.html

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3. **Half-promotion requires 2 moves.**

   It is slightly evolutionary, adding 1 new direction of diagonal movement with unlimited range to the pre-existing directions of movement for a 2-D piece. This can be applied to any piece with 4, 5, 6 or 7 pre-existing directions of movement.

   A 2-D piece undergoing half-promotion retains the entire movement capabilities of its original piece throughout the process.

   The intermediate stage is numbered and color-coded as stage 1 (yellow).

   This upgrade in power is desirable where urgency is a large concern.

   half-promotion
   http://www.symmetryperfect.com/shots/promo/promo-half.html

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emergency options

Sometimes (but not always) the most move-costly conversions can be aborted in favor of a suitable conversion option that is less so when the unforeseen, clever, disruptive behavior of one's opponent derails the most desirable course of action.

The double-promotion of a rook into a royal queen in 4 moves can be aborted in favor of the single-promotion into a choice between a diagon rook I or a diagon rook II in 3 moves.

The single-promotion of a diagon rook (I or II) into a royal queen in 3 moves can be aborted in favor of the half-promotion into a choice between two appropriate, evolutionary 2-D pieces with 7 directions of movement in 2 moves.

The single-promotion of a rook into a diagon rook (I or II) in 3 moves can be aborted in favor of the half-promotion into a choice between four 2-D pieces with 5 directions of movement in 2 moves.

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practical use of conversions

Spherical Chess 324
conversion values
http://www.symmetryperfect.com/shots/texts/convert.pdf

In the opening game, many complex contingencies can be effectively prepared for by elevating 2-D pieces that are vulnerable to distant diagonal attacks and pins (esp. rooks) to 1 conversion stage (i.e., the "yellow" stage) above their ground, zero stage (i.e., the "gray" stage).

All 2-D pieces with 4 or 6 directions of movement at stage 1 are essentially capable of all 8 directions of movement in 2 moves (via a half-promotion move) instead of in 1 move as only a royal queen can. Thus, having all 8 directions of movement available within a 2-move turn via this pivotal, adaptable reaction state until a conversion commitment is required due to game pressures can be desirable. Still, the 1 move per 2-D piece which must be invested to attain this stage 1 capability for it should be prioritized amongst your 2-D pieces. Obviously, this potentially empowers 2-D pieces with only 4 directions of movement (rooks) the most.

In the opening game, 2-D pieces far away from the front lines (i.e., diagon rooks) do not need to be single-promoted in 3 moves as critically as the conversional development, positional development, 2-D piece exchanges and move pressures involving front-line 2-D pieces (i.e., primarily, rooks) need to be managed and protected.

From the opening position, the fastest, most practical method available to initiate a materially-advantageous attack requires 4 positional moves.

[Note: It is to use a diagon rook (I or II) to capture a royal queen belonging to the opponent. One block in its path has to be captured beforehand.]

Half-promotion in 2 moves is the most typically used conversion move with single-promotion in 3 moves occasionally used and double-promotion in 4 moves rarely used.

The main reason that half-promotion is useful and often preferable to single-promotion is, for all practical purposes upon a continuous space 2-D gameboard, 5-directional sliders are almost as effective as 6-directional sliders (diagon rooks) and 7-directional sliders are almost as effective as 8-directional sliders (royal queens). This is due to the ability of a 5- or 7- directional slider to circumnavigate the 2-D gameboard to reach a target 2-D piece in a unique diagonal direction for which it has no opposite pair … unless there is an obstruction (which is sometimes the case).

Half-promotion is more useful during the opening game (where emergency captures occur most) and less useful during the endgame (where material becomes critical).

Although double-promotion in 4 moves is the best value (in terms of diagonal movement gains vs. moves) of all conversion options, it is only used occasionally because that many moves invested are a valuable resource, it is sometimes unsuccessful (i.e., the rook undergoing double-promotion gets captured) and it sometimes has no lasting effect (i.e., the royal queen that was just created from the double-promotion of a rook may get captured in an endgame exchange if both players possess the same number of pieces).

Since the rooks start the game positioned as front line, 2-D pieces, they cannot easily be retreated to anywhere safe to complete double-promotion to royal queens. Otherwise, newly-created, royal queens left on the front lines are an accessible, prime target for capture by one's opponent using lower-value pieces.

Throughout the mid-game, single-promotion is useful occasionally to set-up attacks and double-promotion is useful rarely to create more royal queens (for advantage or survival). Half-promotion remains commonly useful at this point.

The possibility of successfully using double-promotion increases as the potential threats vs. protections against rooks undergoing this 4-move conversion diminishes. In other words, the opportunity during the endgame is likely to arise if one is winning but is unlikely to arise is one is losing.

Double-promotion is less useful during the opening game (where emergency captures occur most) and more useful during the endgame (where material becomes critical).

It is noteworthy that conversional moves (i.e., moves without a change in position), although important, are not generally as valuable or effective as positional moves (i.e., moves without a change in material value) in this game. Positional moves must be more important. Otherwise, at the start of the game, both players might be prone to make no positional moves, preferring instead to first promote all 40 of their pieces (those that do not start the game as royal queens) into royal queens. This would render the game tactically sterile.

Although this is new concept to chess variants, conversion values must be important to Spherical Chess 324 since conversion moves comprise a portion of the moves list in any typical game. As they add to the material values of pieces (which are indisputably important) as they are likely to exist in the near future, they also carry a tactical importance as well as a strategic importance to the material balance existing in the endgame between the players.

The simplicity and clarity of the table of conversion values is appealing and practical to use.

A few facts that are readily-evident can be used as rules to play well conversionally (most of the time):

1. **Half-promotion, with 1/2 of a direction gained per move, in 2 moves should be used, whenever possible, to make emergency captures.**

   The minimal protection rooks are given in the opening setup makes the use of half-promotion subject to consideration.

   Note that whenever half-promotion is initiated for a rook or a diagon rook (I or II), it irreversibly dooms the piece to being promoted into a "five" or "seven", respectively, which in turn, if promoted, can only be inefficiently half-promoted again into a diagon rook or a royal queen.

2. **Single-promotion, with 2/3 of a direction gained per move, in 3 moves should be used but probably cannot be used except occasionally due to the overriding pressure of positional moves against you.**

   The minimal protection rooks are given in the opening setup makes the use of single-promotion ill-advised.

   The moderate protection diagon rooks (I-II) are given in the opening setup makes the use of single-promotion possible but only advisable in special cases and makes the use of half-promotion all the more unnecessary and wasteful of moves.

3. **Double-promotion, with 1 direction gained per move, in 4 moves should be used but probably cannot be used except rarely due to the overriding pressure of positional moves against you.**

   The minimal protection rooks are given in the opening setup makes the use of double-promotion almost impossible. In any case, the continuation of any type of promotion is usually ill-advised for any rook after the opponent has a piece in position to attack it in 1, 2 or 3 moves.

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non-existent zugzwang and 3-fold repetition

Even though passing a move is never allowed, passing a move is never beneficial anyway in the featured game because zugzwang is an extremely rare problem with a possibility of existing only at the endgame for the player who is unavoidably facing imminent defeat, anyway. Otherwise, the complex promotion (half, single and double) scheme nearly always make a productive, conversional move possible even when a productive, positional move (capturing or non-capturing) is not possible.

For a player to be forced to make a bad move during the opening game or mid-game due to severely limited move options is contrary to the spirit of the game and totally unacceptable for a game that is well-designed for adaptability and the wide availability of appropriate, measured responses.

I have not yet seen any evidence that there is a way, in a game with a white-black-black-white turn order, for a player to stubbornly or evasively force his/her opponent into making moves that repeat positions without capturing to loop the game. If I ever do, then I will explicitly make 3-fold repetition a loss for the responsible player on the grounds of bad sportsmanship.

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game-ending conditions

There is only one method of victory- to capture the last royal queen belonging to your opponent. Each player begins the featured game with 8 royal queens. However, the promotion potential of all 40 other 2-D pieces for each player to royal queens is often efficacious.

Moreover, victory can always be achieved in the featured game by capturing the last royal queen. The accessible 2-D gameboard geometry (i.e., any square space can be reached from any other square space in a maximum of 2 moves by a rook- the least powerful 2-D piece a player can possibly own), complete orthogonal movement capabilities of a rook existing as a minimum within ALL 48 pieces used by each player, commonplace double-moves and the various conversions schemes- promotion (half, single and double)- all work together to assure conclusive endgames as quickly as possible.

Draws are impossible via <u>all</u> endgame scenarios. This has been verified thru extensive testing. Very few other chess variants in existence make draws impossible without significantly sacrificing or compromising fairness.

To be bluntly realistic, draws are disastrous failures of a game to function properly by reaching the decisive conclusion it was primarily created and designed to do. To be sure, chess variants holding such a serious design flaw are entirely preventable and as such, are ultimately, entirely the fault of the game inventor- never the players (despite what happens competitively). Draws produce a pointless waste of effort and time in the end. Significantly, draws are most prevalent in the most badly designed games (e.g., Chess).

One important quality of perfect games is that they are absolutely drawless. Furthermore, it is logically arguable (despite being controversial) that ALL 2-player games that do not <u>always</u> determine a winner and a loser with unavoidable, irreversible, steady progress toward its endgame are, in fact, fatally flawed since they do not completely meet the definition of a game as "a contest or competition between two players that results in a winner and a loser".

Every game of Spherical Chess 324 played rationally by at least one out of the two players must end conclusively as a victory for white or black. Deep theoretical insight is not required to be able to force a win whenever possible, either. Usually, how to force a win, as soon as it becomes possible (or shortly thereafter), is obvious to any competent player.

Maximizing fairness without admitting the possibility of draws via conclusive endgames for all possible scenarios entails a few defining characteristics of perfect games. The only theoretical limitation to fairness in conclusively drawless, turn-based chess variants lies in the ramification theory that ultimately all games of this type, if thoroughly calculated and solved [many orders of magnitude out of reach with present-day, state-of-the-art computer technology], must predestine either a win or a loss for white or black with perfect play on the part of both players.

Specifically, a predestined win for white with perfect play on the part of both players is theoretically, tentatively predicted for the featured game due to a probable, razor-thin, first-move-of-the-game advantage for white but this is uncertain and unproven. Of course, just one imperfect move per game by white (presumably, the advantaged player) should make victory achievable for black (presumably, the disadvantaged player), though, thereby eradicating the minuscule, predestined unfairness.

Personally, I would not dare to be quoted making the extremely-hazardous prediction that white is the predestined winner in the featured game. I would prefer to responsibly, factually state that although a predestined winner surely exists, noone has any firm, non-speculative basis for predicting- much less proving- which player it is. This can only be conclusively determined when the featured game is completely calculated thru and solved by a distributive computing network of supercomputers (which is not due to happen anytime soon, if ever).

A possibility should be reserved that the original acceptance of its validity and widespread prevalence of the concept of a first-move-of-the-game advantage (by white) in modern theory and discussions involving chess variants is an implicit consequence of most chess variants having a white-black turn-order where it is well-established and virtually proven to exist.

For chess variants with a different turn-order (including the relevant white-black-black-white turn-order), it can only be responsibly stated with certainty that either a first-move-of-the-game advantage (for white) exists OR a first-move-of-the-game disadvantage (for white) exists. Although I have a reason to suspect the former exists instead of the latter, whichever it is has likewise not yet been conclusively determined.

If absolute, total fairness were achievable for turn-based chess variants, a draw [which is impossible] would instead be predestined for both white and black with perfect play in the featured game as a working model of the ideal, absolutely-perfect balance existing within it.

Conversely, it may seem valid in theory that if the possibility of a draw were admitted (restrictively- under only "seemingly" appropriate, rare circumstances), absolute, total fairness may indeed be achievable. However, I remain unconvinced that this is necessarily correct. Specifically, I am wary of the possibility of failing to notice something relevant or making an error with what is accepted into the concept of an admissible, absolutely fair draw. If a draw is definitively unfair to one player who held an earned advantage and irrefutably could have eventually won if not for his/her opponent being able to prematurely exploit a draw rule, then by definition it cannot be a fair draw.

Ultimately, judging between the disastrous nature and practical, commonplace irritation of drawishness or the extremely-small imperfection in fairness due to drawlessness makes the right decision in this matter obvious with confidence. Besides, the custom of fairly alternating which actual players control white and black is effective at neutralizing or averaging-out all measurable advantages and disadvantages overall wherever an even number of games (i.e., more than 1- an odd number) are played.

Notwithstanding, achieving absolute, total fairness while somehow maintaining drawlessness wherever only ONE game is played is a tantalizingly noble, perfect ideal despite its intransigent impossibility that puts it out of reach. Ultimately, the minimum number of anything required for a symmetrical, balanced relation to have any meaning, exist and apply is TWO, not ONE. Therefore, TWO games (i.e., the minimum, even number) must be played to achieve total fairness.

Although simultaneous-move chess variants have been conceived of naively as a theoretically-perfect solution (being absolutely fair, giving absolutely no advantage or disadvantage to white or black), in reality they are fatally flawed and unplayable since they are catastrophically-unstable defensively (in a state that steadfastly defies correction from my experimental efforts). Moreover, draws must still be admissible and somewhat commonplace.

When one player has his/her last, royal queen captured, their opponent will be either 0 or 1 move ahead (depending upon whether the royal queen capture occurred with the first or second move of the turn). The winner being an average of ½ move ahead after the game-ending move is not a significantly-large problem to fairness over the course of a normal-length game, consisting of at least 40-60 4-move cycles (with an extremely close game requiring appr. 80-100 4-move cycles). In any case, this failure to attain perfect fairness cannot be corrected.

Instead, a significantly-large problem to fairness can exist theoretically within games ended by capturing only ONE of a players' total starting 2-D pieces, designated at the start of the game as the only royal 2-D piece. A definite, sizeable advantage exists for the aggressor over the defender so that the defender needs to be more skilled than the aggressor to have an equal chance of winning.
Even if either player fairly has an approximately equal opportunity to be the first to effectively assume control as the aggressor (only IF the white-black-black-white turn order is used), the viable defensive stability of the game itself designed as such is marginal. [Such a critically-important, foundational feature of a game should <u>not</u> be allowed to exist in a deficient condition.]

This is true to the extreme if there is only ONE royal 2-D piece that has little or no mobility as in most games of the royal king class. Typically, the total material value of one's single royal king is correctly evaluated as more than the value of ALL other non-royal 2-D pieces belonging to one's opponent added together. Unfortunately, such an extreme yet realistic, within-range material value represents a measurable imbalance, unfairness, vulnerability and instability in the game itself available for exploitation by clever players, esp. when they have the first-move-of-the-game advantage by playing white with a white-black turn order.

This is false to the extreme if the number of royal 2-D pieces (royal queens, in the case of Spherical Chess 324) is high (8) at the beginning of the game, they have maximum mobility and the number of potential royal 2-D pieces (via promotion of rooks and diagon rooks into royal queens) is at its maximum (all 40 other 2-D pieces) as in this elimination game of the royal queens class.

The defensively-untenable nature of royal king games compromises and trivializes them as a class compared to their best, theoretical potential as chess variants in general and elimination games, esp. of the royal queens class, in particular (for which there is no exploitative, cheap or quick-and-dirty method of victory achievable by straining the defensive instabilities of the game itself).

A victory by capturing every royal queen of at least 8 on the board (where 40 other 2-D pieces potentially can be promoted to royal queens) belonging to one's opponent is indisputably thorough, complete and fairly earned.

This is the main reason for these 2 classes of games (royal king games and royal queens games) being assessed as at their best, having the potential to be irretrievably, non-trivially imperfect and virtually perfect, respectively.

Due to the mobility existing for the last royal queen, the endgame can become remarkably unfocused, unanchored and complex in addition to being critically important. [Notwithstanding, the complexity of an endgame is vastly outstripped by the complexity of an opening game due to the severely reduced number of pieces typical for an endgame.] Significantly, the last, mobile royal queen may opt for the gambit of being used for attack instead of merely being defended.
Upon a continuous space, 2-D gameboard, any royal queen can potentially be attacked from all 8 angles. Due to the symmetry of the 2-D gameboard, the fatal line of attack against the last royal queen is equally likely to come from any angle.

The critical restriction with exotic 2-D gameboard geometries is that it remains possible for any square space to be reached from any other square space by a rook in a maximum of 2 moves on an ideal, otherwise-empty 2-D gameboard. If not, then inconclusive endgames via perpetual evasion are possible. Note that the critical restriction is made to accommodate a rook instead of a queen as a worst-case scenario. Conclusive endgames can occasionally be rendered more quickly (in one move) using a rook and sometimes more quickly using a queen.

As a universal game-design principle, any conceivable 2-D gameboard geometry that is convex overall in its dimensions must be investigated as an admissible possibility for basing a royal queens game upon (although the simplest, ideal shapes overall that are suitable for games of this class are roughly squares or diamonds).

In the featured game, although any game played can end as a win or loss (for white or black), no game played can possibly end in a draw due to stagnation (i.e., mutual insufficient material, positional inability to reduce opponent's material, irreconcilable standoff, perpetual evasion or repetition). This is an extremely desirable condition for the players- unique to the featured game.

In the featured game, at the greatest reduction of material possible [Obviously, for a game not yet over.], both players must still possess one piece and it must be a royal queen. In part, this is due to its white-black-black-white turn-order.

On an ideal, otherwise-empty 2-D gameboard, the rook is the only 4-directional slider that can force a win in the featured game, regardless of relative positions. Of course, all of the more powerful 2-D pieces that wholly include the orthogonal movements of the rook can force a win as well … sometimes in fewer moves. This explains why every 2-D piece that starts the game on the 2-D gameboard is at least as powerful as the rook and possesses the orthogonal movements of the rook. Notably, this also applies to all transitional 2-D pieces attainable thru the promotion of 2-D pieces that start the game on the 2-D gameboard. Ultimately, <u>all</u> of the 2-D pieces that are or can be used within the game are immediately capable of forcing conclusive endgames.

At the end of the endgame, one player must always be in an advantaged state to force a win. Then, upon the next available double-move (or soon thereafter IF other 2-D pieces obstruct the desired path) can hit the sought, occupied square on the 2-D gameboard and thereby, capture his/her opponent's last royal 2-D piece (royal queen).

The power of the desirable design features of Spherical Chess 324 over their players is absolute. Despite the total freedom each player has over choosing vast numbers of positional or conversional moves per turn, minimal rules, only one method of victory and an astronomical number of material and positional states the endgame can reach …

> **If you do not defeat your opponent, then your opponent will surely defeat you (in every case). No other options really exist.**

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worldview and games

There is no simple cause-&-effect relationship between the universal game-design principles acquired and refined over time and one individual, (hopefully) perfect game. In fact, the featured game was NOT neatly created as the product of a complete, incisive worldview. Conversely, the featured game did NOT suddenly build a complete, incisive worldview.

At the beginning of this project, there was no worldview and there were no games (obviously). Attempts to construct a worldview inspired imperfect games one-at-a-time as attempts to construct perfect games inspired single ideas which cumulatively became part of a complex worldview. A mixture of incisive and mistaken worldviews and games were a part of the philosophical and experimental process at some phases. Eventually, both an insightful worldview and a single, virtually perfect game somehow brought each other into existence thru an intercombinative process involving thousands of cross-references and searches for clues between abstract principles and actual, defined games over years of work.

The inverse relation that inescapably exists between the quantity and quality of the games comprising a collection has been conclusively proven to me by labor-intensive experience. Appr. 1000 sketches or designs have materialized into an est. total of 250 computer-playable, published games out of which only one has survived my relentless quest for perfection (thusfar) despite my hard efforts all along the way to save as many of them as possible thru appropriate revision.

For the sake of only one virtually perfect game, all of the years of work have been well worthwhile to me, though. To be sure, no other chess variant inventors (prolific, selective or single-game) have also invested the years in the appropriate type of theoretical and experimental work required for it to even be possible that ONE of their games is perfect.

Some regard chess variant creation purely as a form of art with as many varying legitimate, equally-meritorious, creative expressions possible as akin to oil painting, for example. Over time, I have grown increasingly skeptical of this view. The numerous, calculable and measurable, mathematical and geometrical qualities intrinsic to ALL chess variants do not exist to be deceptive. Instead, they indicate something important about the basic nature or true definition of chess variants universally.

The fact that chess variants as a class can generally be completely defined and played reasonably-to-extremely well via computers running custom-written AI programs gives strength and all-but-conclusive proof to the assertion that they are indeed mathematical-geometrical entities. Logically, this compels one to strongly suspect that chess variants, at their best, can only be made in accordance with <u>scientific</u> design principles.

Accordingly, my method in creating and revising games was always as mathematical and geometrical as possible. Games that did not meet a large number of strict, principled quality criteria and limits were rarely invented in the first place. Furthermore, games that were not sufficiently unique and appealing relative to one another were not kept. Then, playtesting and critically analyzing the various game features lead to the silent un-invention of most. All of those that remained [only ONE to date] were well-distilled, the best that I (or possibly, anyone) could create.

If I had not limited the number of my endorsed, currently-published creations via a large number of strict, principled quality criteria, then I would have been compelled to invest a huge amount of work toward the unworthy goal of creating a theoretically-unlimited number of poor to average (at best) games. I left this chaotic, pointless pursuit exclusively to several other well-known, prolific, chess variant inventors of seeming brilliance.

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the value of perfect games

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There are many types of mental endeavors that can help people exercise their minds, sharpen their acuity or even, enhance their intelligence slightly-to-moderately over time. I would not assess playing board games as being of greater importance than many other, unrelated (or seemingly so) ways. However, gameplaying is ideal for this purpose due to the great number of events which can be simulated and learned from via feedback within a brief time without risking harm to one's self or others in any non-trivial way (unless gambling is involved).

At a cursory glance, people generally classify games as trivial pursuits. Maybe so. Yet game theory is the most instructive branch of mathematics applicable to areas of life generally agreed to be far more effectual and important than mere parlor games.

Economics, business, political science, revolutionary theory, military science, legal theory, legal practice, legislation, police science, terrorist behavior, criminal behavior, social behavior, etc can all be learned from, to some extent, from the perspective of game theory. Essentially, game theory offers some valuable holistic insights with predictive, empowering or controlling potential into many of the vast number of possible resourceful, rational decisions and moves by governments, corporations and individuals designed to maximize rewards or stability and minimize losses or risks.

Of course, the complexity intrinsic to these non-scientific subjects that do not allow some important variables to be isolated or treated mathematically, gives rise to many errors and limitations. Nonetheless, a wide range of seemingly-unrelated subjects which involve utilitarian behavior and its various methods of calculation can be approached with some fruitfulness by this mathematical science with interdisciplinary value.

The main reason I do not consider chess variants trivial lies in my marginally-tenable theory, ideal or notion that perfect games truly exist within the infinite universe of possibilities. Moreover, I am confident that the efforts of the chess variant community (including myself) to discover or invent perfect games can and eventually, will succeed (if they have not already). Furthermore, I would classify any perfect game created as a perfect model and in turn, value any perfect model very highly instead of trivially as an educational tool which could possibly be catalytic to rapid and/or deep human learning to the greatest extent.

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This extraordinary tool for human learning could have an unprecedented, high positive transfer to other important subjects of study effecting humanity which are also approachable from game theory- the limiting factors involving levels of emergence and mental adaptivity where crossing distinct subject matters.

I venture that an appropriate or correctly applicable parallel or analogy is a limit (in the sense of calculus) whereby perfection is not absolutely achievable but progressively approachable thru the correct solution of as many successive, problem terms or steps as possible. By no means do I regard this parallel or analogy as a perfect fit to our endeavor, though:

1. **I strongly doubt that the number of game-design principles which must be adhered to in order to create the best chess variant possible is infinite (and thus, unachievable). I am aware of only a dozen essential and a dozen non-essential game-design principles which I consider important enough to comply with in every case. After over a decade of thought and work, I have become convinced that I have not overlooked or failed to consider any critically-important topics within our craft.**

2. **The importance of the various problem terms or factors in game design varies greatly. One is most important (symmetry), several are vital, many are of minor-to-trivial benefit ... to comply with. Consequently, I have reasons to think that a board game exhibiting 75%-90% perfection (as if anyone has devised a proven, reliable mathematical method to measure such value-judgment laden qualities) can readily be implemented by anyone with sufficient expertise to follow just several well-defined guidelines.**

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playing considerations

Complex tactics and strategies can be built upon the simple foundation of a single, linear move by the staggering number of relevant, future possibilities (for 2-D pieces promoted or unpromoted) and multi-move approaches.

The 2-D pieces (with their movements) are analogous to simple, moving parts interconnected within a large, complex machine you control, engaged in battle against a large, complex machine controlled by your opponent. One player is destined to perish. The most skillful player is destined to survive albeit barely in many instances.

[Please remember this is only a game?]

To be sure, all sliding 2-D pieces of unlimited range are power 2-D pieces. Considerable pressure exists upon both players from the first move of the game. It should not be surprising that games consisting mainly of sliding 2-D pieces of unlimited range are fast, dangerous as well as alarmingly, irreversibly destructive.

Although all 2-D pieces remaining can theoretically be promoted, potentially as far as omnipotent, royal queens, the number of 2-D pieces remaining will always decrease since every 2-D piece captured can never be replaced. Generally, the featured game is aggressive with appr. 1/3 of the moves in the move list for a typical game consisting of captures.

In the featured game, the conflict between the 2 armies is maximized or sharp focused at the 2 points of intersection along the two diagonal lines that run thru the centers of both armies. At the start of the game, none of these dangerous, confrontational square spaces along the two diagonal lines are occupied.

The most important goal during the opening game is to irrefutably reposition and/or convert your 2-D pieces from their opening setup into a superior, more versatile and capable defensive and offensive arrangement relative to your opponent's 2-D pieces via resourcefulness, adaptation and foresight of a vast number of contingencies. Thereby you create an advantageous asymmetry over your opponent that can be carefully played-out over the course of a game to achieve victory in a surprisingly controlled, routine and (in general) predictable manner as long as you do not make any major mistakes. A superior understanding of the structure and function of the spherical-surface 3-D game in terms of its 2-D gameboards and 2-D pieces is prerequisite to achieving this goal.

The initial dilemma both players find themselves in is that their armies are separated from one another diagonally yet their front-line pieces (rooks) have only orthogonal movement capabilities. For 2-D pieces with only orthogonal movement capabilities, 4 moves are required to reach the opponent's army. For 2-D pieces which also have diagonal movement capabilities, 4 moves are required to reach the opponent's army. Fortunately, all conversional moves (promotions) entail adding needed, diagonal directions of movement to 2-D pieces. This is especially beneficial to rooks.

Although every move within a game is potentially, critically-important since the very next move made can sometimes possibly be the game-winning or game-losing move, the importance of moves made throughout a game is progressively higher toward the beginning of the game, reaching its maximum with the very first move of the game (by white) and reaching its minimum with the very last move of the game. Accordingly, your greatest chances at gaining an irrefutable advantage over your opponent occur at-near the beginning of the game. The best means to do so is definable as devising [from scratch, if necessary], writing down, memorizing and using opening books tailored to the featured game.

Due to the unlimited range of the sliding 2-D pieces, offensive and defensive structures often become interconnected with some 2-D pieces being pivotally usable in both ways. Correctly deciding between many, complex offensive and/or defensive priorities is critically important at numerous moves during a game. Threatening escalations of power 2-D pieces frequently occur which trigger forced lines of play or exchanges of a length and 2-D piece number unparalleled by other chess variants.

Controlling the tempo where 2-move turns are commonplace is important to shaping the game favorably. However, the destiny of the game can be lost by doing so recklessly, by letting a more destructive attack by your opponent continue while you launch a less destructive attack against your opponent to retain possession of the tempo.

More subtly, the positional strength of your 2-D pieces can gradually deteriorate and become inferior to those of your opponent as some moves are wasted when made mainly for the sake of controlling the tempo. Also, your opponent may repeatedly get to use 1 of his/her 2 moves per turn, after capturing your 2-piece used for attack, to promote 2-D pieces and gradually gain a material advantage.

To achieve 2-move captures of highly-valued material often while seldom allowing your opponent to achieve 2-move captures except of lowly-valued material is your primary tactical objective. Incisive, resourceful positional and conversional play is well-rewarded within this 2-moves-per-turn game where the tempo has an amplified importance.

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Capturing neutral 2-D pieces (blocks) is often necessary and can be considered part of the development phase as well as an attack preparation tactic.

Exclusively offensive or defensive strategies will always lead to defeat against a capable opponent. The key to victory lies in being more resourceful than your opponent at handling and balancing both very well simultaneously. In an extremely close game, the winner is the one who is able to maintain adequate, stable defenses with minimal 2-D pieces deep into the endgame while freeing up maximal, available 2-D pieces possible to launch effective offenses which overwhelm the defenses of one's opponent. Superior positional and conversional play is vital to attaining and maintaining material advantages throughout the game leading to victory.

Over the course of the game, exchanges should be managed with extreme care so that you retain an advantage in the number of 2-D pieces. This is instrumental to overwhelming your opponent in the endgame, eventually making their royal queens indefensible and insufficiently replaceable via promotion. Even a small disadvantage in the total number of royal queens, when the number gets low (e.g., 3 or less), is intolerable, though, and must be corrected as soon as possible by any means necessary. Comparatively, the number of royal queens belonging to both players should often be counted and examined positionally and conversionally in terms of safety.

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the branching factor

The theoretical depth of Spherical Chess 324 is tremendous. So, it would be grossly mistaken to pre-judge this game as being recklessly, destructively satisfying yet intellectually worthless. In fact, to such an extreme that playtesting it to a minimal, instructive depth (8-ply) is currently impossible using anything less than a distributive computing network involving thousands of computers. Obviously, a custom-written program with advanced pruning algorithms is needed for any progress to be made past 6-ply within survivable times.

Of course, human vs. computer or computer vs. human games only have instructive, analytical value where the human player actually manages to win against the computer. Losing is just a monumental waste of time, the results being worthless for study to anyone.

The time required for the computer player (white or black) to move in games played at each successively deeper ply will multiply by a very large but precisely-unknown, branching factor which is the average number of legal moves available.

The estimated branching factor for Spherical Chess 324 is roughly determined by 3 variables:

1. **The average number of mobile 2-D pieces upon the 2-D gameboard throughout a game in progress (for a game rationally played by both players).**

   The winning player is guaranteed to and the losing player is probable to finish the game with more than zero 2-D pieces. Thus, the sought number will be somewhat higher than the total number of 2-D pieces at the start of the game (96) and the absolute minimum number of 2-D pieces at the end of the game of more than zero (0). The average is 48. Still, this is a useful minimum figure.

2. **The average number of conversional move options per mobile 2-D piece.**

   [Only 2-D pieces that start the game upon the 2-D gameboard have been taken into account since only they are sure to matter.]

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   This includes half-promotion, single-promotion and double-promotion. Various 2-D pieces used in the opening setup have, in their ground, zero stage and their 1-3 conversion stages, 1-5 conversion options with an overall average of 1.81.

3. **The average number of positional move options per mobile 2-D piece (measured by the number of spaces all mobile 2-D pieces can occupy).**

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   This varies radically during a game, between different types of mobile 2-D pieces and between various 2-D gameboard geometries. So, it is extremely complex and difficult to estimate an average with reliability.

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   At the actual opening setup with 68 blocks dividing both armies, it is precisely measurable at 2.0.

   At the hypothetical opening setup with zero (0) blocks dividing both armies, it is precisely measurable at 8.167 (which is 4.0833 times as high).

   The actual opening setup is not representative of the average state throughout a game in progress since occupancy of the 2-D gameboard is its highest at over 50%, 68 neutral buffer 2-D pieces (blocks) divide both armies to inhibit movement and no promotions (which increase positional move options) have occurred yet. Accordingly, an estimated value over twice as high, 4.0833 (which is an average between the actual opening setup and the hypothetical opening setup) is used as being closer to representative of the average state throughout a game in progress.

This yields a branching factor before advanced pruning of appr. 354.
By comparison, the average branching factor before advanced pruning for Chess is 35 and for Go is 235. Hence, Spherical Chess 324 may be one of the most complex 3-D chess variants in existence if not also one of the most complex board games in existence.

An unknown number of centuries or millennia of progress in computer technology are prerequisite to Spherical Chess 324 being calculated completely thru and solved.

Three related, problematical factors involving branching factors of importance to our craft deserve consideration:

1. **The higher the branching factor of a game, the less effectively it can be played on any state-of-the-art computer running any AI program even with extremely long time controls (due to a combinatorial explosion taking place past its deepest ply that can be completed within a tolerable time). Nonetheless, computer playtesting is vital to proving the stability and overall quality of a game.**

2. **The higher the branching factor of a game, the less impact future advances in computer technology (esp. CPU speed) can possibly have. For example, Spherical Chess 324 has an est. branching factor of over 350. Therefore, if personal computers owned worldwide increased unimaginably in CPU speeds by an average of appr. 122,500-fold, they would only yield the benefit of an additional 2 plies in search completion.**

   Hence, a minimal quality play, 8-ply search completion would become achievable within a survivable time where currently nothing deeper than an unacceptably low-quality play, 6-ply search completion is achievable within a survivable time.

   For perspective, a 10-ply search completion is needed for solid play and a 12-ply search completion is needed for incisive play.

3. **The higher the branching factor of a game, the better its potential quality as expressed in oft-measurable terms such as non-triviality, tactics, strategy, theoretical depth, fairness, balance, equality, stability, symmetry.**

Conclusions-

At least with board games of the chess variant type, the incisiveness with which any program plays a game generally varies inversely with its potential quality and importance. Unfortunately, games with extremely high branching factors are much riskier creations since, by being out-of-reach for modern computer playtesting technology, they cannot be absolutely proven to be well-designed or even, free from fatal or disastrous flaws.

My considered opinion is that serious chess variant inventors should never publish anything with a branching factor lesser than 100-200 yet they must do everything possible, despite limitations, to assure the quality of their gameworks in the absence of the most useful, conclusive test (i.e., incisive computer AI programming and play). Absolute intractability, regardless of future technological improvements, must be expected, though.

Ultimately, when working at such a high level of complexity, it is very easy to invent junk that is very difficult to detect as being junk. That is why it is critically important to ascertain and implement as many quality criteria and sound game-design principles as possible when undertaking such high-end work.

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the future evolution of chess variants

Fortunately, the notion that game evolution will continue to focus upon the natural selection of the “big three” chess variants in the world (Chess, Xiang-Qi, Shogi) exclusively as it always has in the past is becoming an obsolete, untenably-restrictive paradigm. Furthermore, the rate of evolution for chess variants as an entire class is increasing in the modern era (and it will inevitably have powerful effect beyond our small community). Travel, communications, media and esp. computer-related technologies all play a part.

In my assessment, the various chess variant engines represent a quantum leap of progress. Although some may estimate their overall importance to be drastically less today, in retrospect they will be recognized as the first evolutionary milestones and a radical, irreversible break with the glacial rate of game evolution of the past (extending deep into the recorded history of civilization). Still, dramatic change with respect to what is popular within societies worldwide cannot realistically be expected to occur quickly, within our brief lifetimes.

I have some confidence in long-term improvements due to an evolutionary process (more similar to the principle of buoyancy) whereby the games of highest quality will eventually get "stirred to the top of the mix" where they will remain, due to their merits, to hold the attention of knowledgeable players and analysts ... until/unless something better comes along.

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physical 3-D chess variants

The main problem with ALL desired, physical 3-D game designs (where a maximum of 26 directions of movement exist) lies in the inability for any cube to be occupied from any other cube by a 3-D piece capable of 26 directions of linear movement within less than 3 moves, without exceptions. The white-black-black-white turn-order [which is optimum and must not be abandoned] requires a capture to be possible within a 2-move turn to insure conclusive endgames.

Although a desperate solution can be devised such as a white-black-black-black-white-white turn order or a white-white-black-black-black-white turn order, few people (including myself) would want to play "a triple-move 3-D game beginning with a single-move or a double-move by white", respectively.

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human wit vs. artificial intelligence

**Essentially, chess variants are complex, dynamic mathematical machines.
As structure defines function, more incisive lines of play progressively approach defining a game itself geometrically thru its best resourceful, holistic, long-range possibilities (i.e., moves) within its characteristic, limited universe- a dynamic, mathematical machine.**

In my opinion, great play at chess-related games reaches a level of abstraction where it is difficult to distinguish or correctly attribute the qualities responsible. Science or art, calculation or understanding, knowledge or imagination, logical programming or intuition to survive- which opposite methods or qualities are strongest in our era? Personally, I hope the best chess-related games invented (or yet to be invented) will be ruled by talented humans instead of computers for a long while to come.

Generally, high-quality chess variant programs require a great amount of time to play most games that are not closely-related to Chess reasonably well (and some games, they cannot play well at all) yet most intelligent people can beat them at most games they dedicate themselves to playing.

I welcome thoughtful, constructive correspondence from anyone.

Please report any errors or inefficiencies observed or discovered thru playing my game or upon examining its programming directly to me via my current and long-standing E-mail address:

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