

Theory of fun for game design Academic PDF

Theory of fun for game design is a foundational concept that guides game developers and designers in creating engaging, compelling, and enjoyable experiences for players. Understanding what makes a game fun is essential to crafting gameplay mechanics, narratives, and aesthetics that resonate with audiences. The theory of fun explores the psychological and emotional factors that contribute to player engagement, offering insights into how games can evoke feelings of challenge, mastery, and immersion. By applying these principles, designers can develop games that are not only entertaining but also memorable and meaningful.

Understanding the Core of the Theory of Fun

Defining Fun in Games

Fun is a complex and subjective experience that varies from person to person. In the context of game design, fun often relates to feelings of excitement, satisfaction, challenge, and immersion. It can stem from a sense of achievement, exploration, social interaction, or narrative engagement. Recognizing that fun is not a one-size-fits-all concept allows designers to tailor their creations to diverse audiences.

The Psychological Foundations of Fun

The theory of fun is rooted in psychology, particularly in theories of motivation and flow. Key concepts include:

- **Intrinsic Motivation:** The internal desire to engage in an activity because it is inherently enjoyable.
- **Flow State:** A mental state where players are fully immersed and focused, experiencing a balance between challenge and skill.
- **Reward Systems:** Mechanisms that reinforce desired behaviors and enhance feelings of accomplishment.

Elements That Contribute to the Theory of Fun in Game Design

Challenge and Mastery

One of the most critical aspects of fun is providing appropriate levels of challenge that encourage players to develop skills and achieve mastery.

- **Progressive Difficulty:** Games should gradually increase in difficulty to maintain engagement without causing frustration.
- **Skill Development:** Offering opportunities for players to learn and improve ensures a sense of growth and competence.
- **Clear Goals:** Defining objectives helps players understand what they need to accomplish, fostering motivation.

Autonomy and Choice

Giving players freedom and agency enhances their sense of ownership and investment in the game.

- **Player Agency:** Allowing players to make meaningful decisions impacts their emotional connection to the game.
- **Multiple Paths:** Providing different routes or strategies increases replayability and personalization.
- **Customization:** Features that let players personalize their experience boost engagement.

Immersion and Narrative

A compelling story and immersive environment draw players into the game world, making the experience more enjoyable.

- **Storytelling:** Well-crafted narratives evoke emotions and motivate continued play.
- **World-Building:** Detailed, believable worlds enhance immersion.
- **Visual and Audio Design:** Aesthetic elements support storytelling and mood.

Feedback and Rewards

Immediate and meaningful feedback sustains motivation and guides players toward goals.

- **Positive Reinforcement:** Rewards and praise encourage continued effort.
- **Progress Indicators:** Visual cues like scores or progress bars motivate players to improve.
- **Balanced Penalties:** Challenges or setbacks should be fair and not discouraging.

Applying the Theory of Fun in Game Design Process

Designing for Engagement

To create fun experiences, designers should integrate elements that promote challenge, autonomy, and immersion from the outset.

- **Player-Centered Design:** Understanding target audiences helps tailor experiences to their preferences.
- **Iterative Testing:** Playtesting allows designers to refine mechanics and ensure balanced difficulty.
- **Focus on Flow:** Striving for a seamless balance between challenge and skill keeps players in the flow state.

Balancing Difficulty and Accessibility

While challenge is essential, it must be balanced with accessibility to prevent frustration.

- **Adaptive Difficulty:** Dynamic adjustments based on player performance can maintain engagement.
- **Assist Features:** Options like hints or adjustable controls support diverse skill levels.
- **Progressive Complexity:** Gradually introducing mechanics prevents overwhelm.

Encouraging Social Interaction and Community

Many players find fun through social engagement within games.

- **Multiplayer Modes:** Cooperative or competitive gameplay fosters social bonds.
- **Shared Achievements:** Leaderboards and achievements motivate players through social recognition.
- **Community Building:** Forums, events, and user-generated content enhance long-term engagement.

The Role of Aesthetics and Art in the Theory of Fun

Visual and auditory elements significantly influence perceived fun.

- **Consistent Artistic Style:** A cohesive aesthetic enhances immersion and emotional response.
- **Sound Design:** Music and sound effects support mood and feedback mechanisms.
- **Visual Feedback:** Animations and visual cues reinforce player actions and achievements.

Challenges and Limitations of the Theory of Fun

While the theory provides valuable insights, it is not without challenges.

- **Subjectivity of Fun:** Individual differences make universal formulas difficult.
- **Cultural Variability:** Cultural backgrounds influence what players find enjoyable.
- **Balancing Innovation and Tradition:** Pushing boundaries can risk alienating players seeking familiar experiences.

Future Directions in the Theory of Fun for Game Design

Advancements in technology, such as virtual reality, augmented reality, and AI, continue to evolve the understanding of fun.

- **Personalized Experiences:** AI-driven customization can tailor gameplay to individual preferences.
- **Immersive Technologies:** VR and AR offer new avenues for immersing players in game worlds.
- **Data-Driven Design:** Analytics help identify what aspects of a game contribute most to fun and engagement.

Conclusion: Crafting Fun Through Informed Design

The **theory of fun for game design** serves as a vital framework for creating engaging experiences that resonate with players. By understanding the psychological principles behind fun—such as challenge, mastery, autonomy, and immersion—designers can craft games that captivate and entertain. Balancing difficulty, offering meaningful choices, fostering social interactions, and leveraging aesthetic elements all contribute to a compelling game experience. Although fun remains a subjective concept, applying these core principles helps developers create games that are not only enjoyable but also impactful and memorable. As technology advances, ongoing research into the nature of fun will continue to refine game design practices, ensuring that players around the world find joy and fulfillment in their gaming adventures.

Theory of Fun for Game Design

In the rapidly evolving landscape of interactive entertainment, the concept of what makes a game truly engaging and memorable remains a central concern for designers, developers, and players alike. At the heart of this discourse lies the Theory of Fun for Game Design, a framework that seeks to decode the elusive qualities that turn mere mechanics into compelling experiences. Originally

popularized by game designer Raph Koster in his influential book *A Theory of Fun*, this concept has become a cornerstone for understanding the psychology of engagement and the craft of creating games that resonate deeply with players.

In this article, we will explore the Theory of Fun in detail, dissect its core principles, and understand how it can be employed to craft games that are not only entertaining but also meaningful and enduring.

Understanding the Core of the Theory of Fun

The Theory of Fun posits that fun arises from the challenge of mastering patterns and systems within a game. It shifts the focus from superficial entertainment to a deeper engagement rooted in learning, discovery, and achievement. Instead of simply providing instant gratification, the game becomes a platform for players to experience growth, competence, and the joy of problem-solving.

The Fundamental Premise: Learning as the Basis of Fun

At its core, the theory suggests that humans are naturally wired to seek out patterns, learn new skills, and overcome challenges. When a game offers a manageable challenge that aligns with the player's current skill level, it creates a state of flow—an optimal experience characterized by focused immersion and satisfaction.

However, if the challenge is too easy, boredom ensues; if too difficult, frustration takes over. The sweet spot lies in progressively increasing complexity, allowing players to learn and conquer at a comfortable pace. This dynamic fosters a sense of mastery and, consequently, fun.

The Role of Patterns and Systems

Games are fundamentally about systems—rules, mechanics, narratives, and feedback loops. The Theory of Fun emphasizes that engaging games are those that present meaningful patterns for players to recognize and manipulate, enabling them to predict outcomes and feel a sense of control.

For example, a puzzle game like Tetris offers clear patterns and predictable behaviors that players learn and exploit, creating a rewarding loop of mastery. Similarly, role-playing games (RPGs) provide systems of character progression, item management, and narrative branching that invite players to explore and understand complex interactions.

Key Principles of the Theory of Fun

To leverage the Theory of Fun effectively, designers should consider several fundamental principles that underpin what makes a game engaging over the long term.

- Progressive Mastery

A cornerstone of the theory is the idea that fun is derived from the sense of achievement that comes with mastering increasingly complex skills or systems. Games should be designed with clear learning curves, allowing players to:

- Build foundational skills early
- Encounter new challenges that stretch their abilities
- Experience a sense of accomplishment as they overcome these challenges

Implementation Tips:

- Introduce new mechanics gradually
- Use tutorials and onboarding processes to scaffold learning
- Design levels or challenges that escalate in difficulty

- Meaningful Feedback

Effective feedback loops reinforce learning and encourage continued engagement. Players need to see the consequences of their actions, whether through visual cues, scoring systems, or narrative developments.

Implementation Tips:

- Use visual and auditory cues to indicate success or failure
- Incorporate reward systems that acknowledge mastery
- Avoid feedback that is delayed or ambiguous

- Pattern Recognition

Games should present patterns that players can discern and manipulate. Recognizing these patterns provides a sense of control and mastery, deepening engagement.

Implementation Tips:

- Design puzzles or mechanics with recognizable patterns
- Gradually introduce new patterns as players progress
- Encourage experimentation to discover underlying systems

- Variety and Novelty

While patterns are crucial, monotony kills fun. Introducing variety keeps players curious and motivated.

Implementation Tips:

- Mix different types of challenges
- Add new mechanics or environments periodically
- Surprising players with unexpected twists

- Alignment with Player Interests

A game that aligns with a player's personal interests or intrinsic motivations will naturally be more engaging.

Implementation Tips:

- Offer customization options
- Incorporate themes that resonate with the target audience
- Allow players to set their own goals within the game

Applying the Theory to Game Design

Understanding the principles is only the first step; applying them effectively requires deliberate design choices.

Designing for Flow

Flow, a concept introduced by psychologist Mihaly Csikszentmihalyi, is central to the Theory of Fun. Achieving flow involves balancing challenge and skill, providing clear goals, and offering immediate feedback.

Practical Strategies:

- Use adaptive difficulty to match player skill levels
- Set short-term goals to give players a sense of progress
- Minimize frustration through forgiving checkpoints or hints

Creating Meaningful Challenges

A game should present challenges that are neither trivial nor insurmountable. The challenge should be aligned with the player's growing skills, fostering a sense of progression.

Examples:

- Puzzle mechanics that evolve in complexity
- Enemy encounters that require mastering new tactics
- Missions that encourage strategic thinking

Encouraging Mastery and Personal Growth

Players derive fun from the sense that they are improving and gaining competence. Designing systems that reward mastery reinforces this.

Implementation Tips:

- Incorporate skill trees or upgrade systems
- Use leaderboards or achievement systems
- Offer optional content for dedicated players seeking mastery

Balancing Repetition and Novelty

Repetition can reinforce skills but risks boredom. Striking a balance by introducing new mechanics or variations maintains engagement.

Strategies:

- Rotate themes or environments
- Introduce new mechanics gradually

- Use narrative developments to refresh context

The Limitations and Critiques of the Theory

While the Theory of Fun offers valuable insights, it is not without limitations.

Overemphasis on Mastery

Focusing solely on pattern recognition and mastery may overlook other forms of engagement, such as storytelling, social interaction, or aesthetic appeal. Some players find fun in exploration, emotional narratives, or community participation rather than system mastery.

Cultural and Individual Differences

What is fun for one player may be tedious for another. The theory assumes a universal desire for mastery and pattern recognition, but personal preferences vary widely.

The Risk of Over-Complexity

Designers might overcomplicate systems in pursuit of deeper mastery, leading to cognitive overload and frustration rather than fun.

Integrating the Theory with Broader Game Design Principles

The Theory of Fun should be seen as part of a holistic approach to game design, integrated with other principles such as:

- Narrative Engagement: Storytelling can complement mastery by providing context and emotional investment.
- Social Interaction: Multiplayer features can add layers of challenge and cooperation.
- Aesthetic Appeal: Visual and audio design can enhance immersion and enjoyment.

By combining these elements with the core principles of fun derived from mastery and pattern recognition, designers can craft richer, more compelling experiences.

Conclusion: The Enduring Relevance of the Theory of Fun

The Theory of Fun for Game Design remains a foundational concept for understanding what makes games engaging and memorable. Rooted in psychological insights about learning, mastery, and pattern recognition, it provides a practical framework for designing experiences that captivate

players and foster long-term enjoyment.

While it is not a one-size-fits-all solution, when applied thoughtfully, the principles derived from this theory can elevate game design from mere mechanics to meaningful, immersive journeys. As the industry continues to evolve, the core idea that fun stems from the challenge of mastery will undoubtedly remain relevant, guiding designers to create games that are not only entertaining but also personally enriching for players worldwide.

QuestionAnswer What is the core idea behind 'The Theory of Fun for Game Design' by Raph Koster? The core idea is that games are enjoyable because they offer meaningful learning experiences, where players find fun through mastering patterns and overcoming challenges, leading to a sense of achievement and engagement. How does the book explain the relationship between challenge and fun in game design? The book emphasizes that balanced challenges that match players' skill levels create flow and enjoyment, while too easy or too difficult experiences can diminish fun. Good game design involves progressively increasing complexity to keep players engaged. What role do patterns play in making games fun according to the theory? Patterns are fundamental because they allow players to recognize, understand, and master them, which provides a sense of progress and mastery, thereby making the game engaging and fun. How does 'The Theory of Fun' relate to learning and mastery in games? It suggests that fun arises from the process of learning new patterns, skills, or concepts, and the satisfaction derived from mastering them, turning gameplay into a form of meaningful learning. What are some practical implications of the theory for game designers? Game designers should focus on creating systems that encourage pattern recognition, provide meaningful feedback, and balance challenge and skill to foster a sense of mastery and ongoing engagement. According to the book, why do people find certain games more fun than others? People find certain games more fun because those games offer the right balance of challenge, pattern complexity, and opportunities for mastery, which keep players engaged and motivated through continuous learning and achievement.

Related keywords: game design, fun theory, game mechanics, player engagement, game psychology, interactive design, entertainment, game development, user experience, playability

An introduction to ergodic theory graduate texts i

An introduction to ergodic theory graduate texts i serves as a foundational guide for graduate students venturing into this fascinating branch of mathematics. Ergodic theory, at its core, explores the long-term average behavior of dynamical systems and their statistical properties. It has profound applications across mathematics, physics, and even in fields like economics and computer science. For students beginning their journey, selecting the right graduate texts is crucial for building a solid

understanding, developing intuition, and engaging with current research directions. This article aims to provide a comprehensive overview of essential ergodic theory texts, their key features, and how they can serve as effective learning tools.

Understanding the Foundations of Ergodic Theory

Before diving into specific texts, it's important to understand what ergodic theory encompasses and why it's a vital area of study. This section offers a brief overview of the fundamental concepts and the scope of graduate-level texts.

What is Ergodic Theory?

Ergodic theory studies the behavior of measure-preserving transformations on probability spaces. Essentially, it addresses questions like: How do points in a dynamical system distribute over time? Do the time averages of functions along trajectories converge to space averages? These questions are rooted in the ergodic hypothesis, which originated from statistical mechanics.

Key concepts include:

- Measure-preserving transformations
- Ergodicity and mixing
- Invariant measures
- Birkhoff's Ergodic Theorem
- Unique ergodicity

Understanding these ideas lays the groundwork for exploring more advanced topics covered in graduate texts.

Essential Graduate Texts in Ergodic Theory

Choosing the right textbooks is essential for mastering ergodic theory. The following sections highlight some of the most influential and widely recommended graduate-level texts, discussing their strengths and targeted audiences.

1. "An Introduction to Ergodic Theory" by Peter Walters

Walters' book is often considered a classic starting point for graduate students.

Key features:

- Clear and rigorous presentation
- Focuses on measure-theoretic foundations
- Covers fundamental theorems such as Birkhoff's and von Neumann's
- Includes numerous exercises for practice

This text is ideal for students new to the field, providing a solid theoretical foundation before moving to more specialized topics.

2. "Ergodic Theory" by Karl Petersen

Petersen's work is comprehensive and slightly more advanced.

Key features:

- Emphasizes both measure-theoretic and topological dynamics
- Discusses entropy, mixing, and applications
- Contains detailed proofs and examples
- Suitable for students with some background in measure theory and topology

This book bridges foundational concepts with more recent developments, making it a good next step after Walters.

3. "Introduction to Ergodic Theory" by Ya. G. Sinai

Sinai's text offers a blend of intuition and formalism.

Key features:

- Focuses on the intuition behind the theorems
- Connects ergodic theory with statistical mechanics
- Includes historical notes and motivations
- Suitable for students who prefer a conceptual approach

Additional Resources and Advanced Texts

Graduate students aiming to deepen their understanding should explore more specialized and advanced texts. Here are some noteworthy options:

1. "Ergodic Theory and Differentiable Dynamics" by Anatole Katok and Boris

Hasselblatt

This comprehensive volume covers a broad spectrum of topics.

Highlights:

- Smooth ergodic theory
- Hyperbolic systems and Anosov diffeomorphisms
- Structural stability
- It is suitable for students interested in the interface between ergodic theory and differential dynamics.

2. "Measure Theory and Probability" by Malcolm Adams and Victor Guillemin

While broader in scope, this book provides valuable measure-theoretic background essential for advanced ergodic theory.

Strategies for Studying Ergodic Theory Graduate Texts

Mastering ergodic theory requires more than just reading; active engagement is key. Here are some tips for making the most of these texts:

- **Start with the basics:** Ensure a solid understanding of measure theory, topology, and functional analysis.
- **Work through exercises:** Practice problems reinforce concepts and develop problem-solving skills.
- **Supplement with lectures and seminars:** Engage with online courses or university seminars for different perspectives.
- **Form study groups:** Discussing complex topics with peers enhances understanding.
- **Connect theory to applications:** Explore how ergodic theory applies to physics, information theory, and other fields.

Conclusion

An introduction to ergodic theory graduate texts provides a roadmap for students embarking on this mathematical journey. Starting with foundational books like Walters' "An Introduction to Ergodic Theory" offers an accessible entry point, while advanced texts like Katok and Hasselblatt's work open doors to current research areas. By selecting appropriate resources, actively engaging with the material, and connecting theory with applications, students can develop a deep and lasting

understanding of ergodic theory. Whether your interest lies in pure mathematics, statistical mechanics, or dynamical systems, the right graduate texts are invaluable tools for your academic and research pursuits in ergodic theory.

An Introduction to Ergodic Theory Graduate Texts: A Comprehensive Guide for Students and Enthusiasts

Embarking on the study of ergodic theory graduate texts opens a gateway to a rich and profound branch of mathematics that intersects dynamical systems, measure theory, probability, and statistical mechanics. For graduate students venturing into this field, selecting the right textbooks can significantly influence their understanding and appreciation of the subject. This guide aims to shed light on the foundational texts, their structure, strengths, and how they serve as stepping stones into the depths of ergodic theory.

Understanding the Foundations of Ergodic Theory

Before diving into specific texts, it's crucial to grasp what ergodic theory entails. At its core, ergodic theory studies the long-term average behavior of dynamical systems with an invariant measure. Its applications range from statistical physics and information theory to number theory and chaos theory.

Key concepts include:

- Measure-preserving transformations
- Invariant measures
- Ergodicity and mixing
- Birkhoff's Ergodic Theorem
- Ornstein's theory of Bernoulli flows

Graduate texts in ergodic theory typically assume familiarity with measure theory, topology, and basic dynamical systems, making it a challenging yet rewarding subject for advanced students.

The Landscape of Graduate Texts in Ergodic Theory

Choosing a graduate-level textbook involves understanding its approach, prerequisites, and depth. The major texts in the field can generally be categorized based on their focus: foundational theory, applications, or a blend of both.

Classic and Seminal Texts

- "Ergodic Theory" by Peter Walters

- Overview: Widely regarded as a definitive introductory textbook, Walters' "Ergodic Theory" is praised for clarity, rigorous proofs, and comprehensive coverage.
- Scope: It covers measure-preserving transformations, ergodic decomposition, mixing properties, and entropy.
- Strengths:
 - Well-structured for graduate courses
 - Emphasizes the connection between measure theory and dynamics
 - Includes numerous examples and exercises
- Prerequisites: Measure theory, basic topology, and some familiarity with dynamical systems.

- "An Introduction to Ergodic Theory" by Peter Walters

- Often considered the go-to text for graduate students or advanced undergraduates beginning the subject.
- Focuses on core concepts with detailed proofs.
- Suitable as a primary textbook or supplementary resource.

Advanced and Specialized Texts

- "Ergodic Theory via Joinings" by Eli Glasner

- Overview: Focuses on joinings, a sophisticated tool in ergodic theory, providing a modern perspective.
- Audience: More suitable for students who have already mastered the basics and want to explore advanced topics.
- Features: Incorporates recent developments, emphasizing the structural and classification aspects of ergodic systems.

- "Entropy, Large Deviations, and Statistical Mechanics" by David Ruelle

- While broader in scope, this text delves into the thermodynamic formalism, a key area in ergodic theory.

- Ideal for students interested in the applications of ergodic theory in statistical physics.

Textbooks with a Focus on Applications or Interdisciplinary Approaches

- "Ergodic Theory: with a view towards Number Theory" by Manfred Einsiedler and Thomas Ward

- Overview: Connects ergodic theory with number theory, providing applications to problems like equidistribution and primes.

- Features: Combines rigorous theory with motivating applications, making it accessible and engaging.

How to Choose the Right Graduate Text in Ergodic Theory

When selecting a textbook, consider the following factors:

- Prerequisites: Ensure you have a solid background in measure theory and topology.
- Focus Area: Decide whether you want a foundational understanding or a focus on particular applications.
- Depth: Some texts offer a broad overview, while others delve into specialized topics.
- Teaching Style: Supplementary materials, exercises, and clarity of exposition can greatly impact your learning.

Recommended approach:

- Start with Walters? "Ergodic Theory" for a comprehensive foundation.
- Use other texts, like Glasner?s "Ergodic Theory via Joinings," for advanced topics.
- Supplement with research papers and lecture notes for recent developments.

Structuring Your Study of Ergodic Theory

To maximize your understanding, consider a structured approach:

- Build a Strong Measure Theory Foundation
- Review measure spaces, sigma-algebras, and integration.

- Study probability theory basics, as ergodic theory often involves probabilistic concepts.
- Understand Dynamical Systems
- Familiarize yourself with topological and measurable dynamics.
- Explore examples like rotations, shifts, and hyperbolic systems.
- Dive into Core Ergodic Concepts
- Invariant measures and ergodicity
- Birkhoff's Ergodic Theorem
- Mixing properties and their implications
- Explore Advanced Topics
- Entropy theory
- Ornstein's isomorphism theorem
- Joinings and structural classification
- Connections with number theory and statistical mechanics

Supplementary Resources and Learning Strategies

- Lecture series: Many universities offer free lecture notes; for example, the lecture series by Peter Walters or others available online.
- Problem sets: Practice through exercises in textbooks or problem books.
- Research papers: Engage with current developments by reading papers in journals like Ergodic Theory and Dynamical Systems.
- Discussion groups: Join seminars or study groups focused on ergodic theory.

Conclusion

An introduction to ergodic theory graduate texts is essential for anyone aiming to master the subject at an advanced level. The journey begins with foundational texts like Peter Walters' "Ergodic Theory," which offers clarity and depth, and then progresses into more specialized or

application-driven materials. By understanding the structure, prerequisites, and scope of these texts, students can tailor their learning path effectively. With dedication, rigorous study, and engagement with supplementary materials, mastering ergodic theory becomes an achievable and intellectually rewarding pursuit.

Final Tips

- Be patient: The subject is challenging but immensely rewarding.
- Connect theory with examples: Visualize systems like rotations or shifts.
- Engage actively: Solve problems and participate in discussions.
- Keep abreast of current research: This enriches your understanding and opens new avenues.

Embark on this mathematical voyage with confidence?ergodic theory offers profound insights into the behavior of complex systems and the nature of randomness and order in mathematics.

Question What is the primary focus of 'An Introduction to Ergodic Theory' by Peter Walters? The book provides a rigorous introduction to ergodic theory, focusing on measure-preserving transformations, ergodic theorems, and their applications in dynamical systems and statistical mechanics. Which prerequisites are recommended before studying this text? A solid background in measure theory, real analysis, and basic topology is recommended to fully grasp the concepts presented in the book. How does the book approach the topic of ergodic theorems? It systematically introduces the mean and pointwise ergodic theorems, providing proofs and discussing their implications in the context of dynamical systems. Are there applications of ergodic theory discussed in this graduate text? Yes, the book explores applications such as statistical properties of dynamical systems, mixing, and entropy, illustrating how ergodic theory connects to various fields. Is this book suitable for self-study or primarily for classroom use? While designed as a graduate textbook, it is also suitable for self-study due to its clear explanations, though some background in measure theory is helpful. What makes 'An Introduction to Ergodic Theory' by Walters a trending choice among graduate texts? Its comprehensive coverage, clear exposition, and balance between theory and applications have made it a popular and influential resource in the field of ergodic theory.

Related keywords: ergodic theory, measure theory, dynamical systems, invariant measures, ergodicity, mixing, entropy, Birkhoff's theorem, stationary processes, ergodic decomposition

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