Complex Dynamics & Phase Transitions Caused by Human Fuzzy Rationality

Ihor Lubashevsky¹ and Dmitry Parfenov²

¹ University of Aizu, Aizu-Wakamatsu City, Fukushima, Japan

² General Physics Institute, Russian Academy of Sciences, Moscow



Human Fuzzy Rationality and Concept of Dynamical Traps

phase space $\{x, y\}$

if human perception were strictly rational

 $\boldsymbol{\chi}$

 $\tau \frac{dx}{dt} = P(x, y)$ $\tau \frac{dy}{dt} = Q(x, y)$ P(x, y) = 0 Q(x, y) = 0

 $U(x, y) \Rightarrow \max$

stationary point

 $\{x_{\mathrm{st}}, y_{\mathrm{st}}\}$

stable or unstable

y y y_{st}

 X_{st}

 $|U(x,y) - U_{\max}| \sim \Theta \left| \bigcup_{y \to \infty} \begin{pmatrix} x \\ y \end{pmatrix} \sim \begin{pmatrix} x_{\mathrm{st}} \\ y_{\mathrm{st}} \end{pmatrix} \right|$

Fuzzy Rationality

person just cannot "see" the point $\{x_{st}, y_{st}\}$

dynamical traps

Region of

Concept of Dynamical Traps



Lazy bead model



Structure of the phase plane {*x*,*v*}



Phase-space density depending on the system parameters



Phase transition mechanism – symmetry breakdown

of

system distribution in trapping region due to the trapping region boundaries being different in properties because of "interaction" of regular forces and white noise



Long lived state multitude

Pattern of 200 bead paths



1 – low density, **2** – high density



1 – low density, **2** – high density



weak dissipation

symmetry parameter

1 – low density, **2** – high density



strong dissipation

relative velocity

1 – low density, **2** – high density



1 – low density, **2** – high density



strong dissipation

1 – low density, **2** – high density



Regular pattern formation in systems without noise



Weak phase transition: 30 bead chain: Phase portrait of middle bead Regular Bead Motion ↔ Cooperative Chaotic Bead Motion





Weak phase transition: 30 bead chain: Phase portrait of middle bead Regular Bead Motion ↔ Cooperative Chaotic Bead Motion

 $\epsilon > \epsilon_{c1} \sim 0.015$

Cooperative Chaotic Dynamics

N = 30, epsilon = 0.02, del = 0.03, sigma = 1.00, sigma_0 = 0.01



Strong transition: 30 bead chain: Phase portrait of two neighboring beads Cooperative Chaotic Bead Motion ↔ Irregular Bead Motion

 $\epsilon < \epsilon_{c2} \sim 0.255$

Cooperative Chaotic Dynamics

N = 30, epsilon = 0.25, del = 0.03, sigma = 1.00, sigma_0 = 0.01



Strong transition: 30 bead chain: Phase portrait of two neighboring beads Cooperative Chaotic Bead Motion ↔ Irregular Bead Motion

 $\epsilon > \epsilon_{c2} \sim 0.255$

Totally Irregular Dynamics

N = 30, epsilon = 0.30, del = 0.03, sigma = 1.00, sigma_0 = 0.01



Multi-scale attractor: 1 bead, weak dissipation



Conclusion

Human Fuzzy Rationality

Dynamical Traps

Many particle systems

Non-equilibrium Phase Transitions of New Type

Weak phase transitions: Noise-induced attractors