

# 5<sup>th</sup> World Congress on Physics

July 17-18, 2018 Prague, Czech Republic



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## Faraway particles have a strong and fast effect on molecular behavior

Molecular systems show Lyapunov instability, i.e. deterministic chaos. For the example of liquid water the magnitude of an introduced perturbation increases by a factor of 10 every 0.23 ps as evaluated from molecular-dynamics simulations. In chaos theory, the consequence is typically stated such that a prediction is impossible on intermediate timescale. The reason is that for the regarded system for every 0.23 ps farther into the future the starting conditions would need to be known by one more decimal digit, which quickly becomes practically infeasible. The interaction of a faraway particle influences any observed molecule minimally, which due to the Lyapunov instability leads to a realizable shift in molecular behavior within at most 33 ps even for particles interacting from the end of the observable universe. Particles farther away do not have a lesser influence but rather the time until the effect of the interaction reaches a given magnitude is slightly longer. Of course the speed at which the interaction travels has to be accounted for, which does not alter the outcome in principle. This effect does not only describe the result of chaos theory expressed as our practical inability to perform predictions but rather relates to interactions between particles and their effect in reality. If any interacting particle would be in a slightly different place, the observed system would behave differently after only some ps. This establishes a highly interconnected network of influences between all particles in the universe.

## Biography

Andreas Pfennig is a full Professor at the University of Liège, Belgium, in the area of Chemical Engineering since four years. He received his PhD from RWTH Aachen, Germany, in 1987. After his Post-doctoral studies at TU Darmstadt, Germany, he became full Professor at RWTH Aachen in 1995. He has published two books, 12 book chapters, more than 80 publications in peer-reviewed journals and presented his research in almost 300 presentations.

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