Nonlinear Dynamics, Psychology, and Life Sciences, Vol. 20, No. 4, pp. 568-569.

Book Review

Modeling Love Dynamics by Sergio Rinaldi, Fabio Della Rossa, Fabio Dercole, Alessandra Gragnani and Pietro Landi. Singapore: World Scientific, 2016, ISBN 978-981-4696-31-9. 241 pages.

This is a book that has waited for centuries to be written. It had to await the development of dynamical systems theory. It had to await the widespread availability of digital computers to solve systems of nonlinear ordinary differential equations (ODEs) and to display the solutions in easily understood ways. Finally, it had to await the acceptance by (at least some) psychologists and sociologists that something as complex as love could be described by simple mathematical models.

There are abundant reasons to be skeptical that romance can be modeled mathematically. How does one even define love in its many manifestations, much less quantify it? How does one account for the myriad of factors that influence the feelings that two (or more) people have for one another? How does one choose among the unlimited variety of possible nonlinear models? Finally, how does one test the accuracy and reliability of those models?

Rinaldi and his collaborators are not the first to venture into this realm. A whole generation of students and researchers first encountered the idea in a short section of the popular textbook by Strogatz (1994) who used it to motivate students to learn about linear dynamical systems and who once cautioned me that if I tried to publish something on the subject in a psychology journal, that the psychologists would take it too seriously. The only other comparable book of which I'm aware is The *Mathematics of Marriage* by Gottman, et al. (2002), but it considers only a limited range of much simpler models and only in discrete time, and it ignores the important falling-in-love stage.

By contrast, Rinaldi, et al. have elevated the subject to a whole new level by presenting a succession of progressively more complicated continuous-time dynamical models and offering plausible support for those models from romantic films and literature. They attempt to predict the evolution of a romantic relationship from its very beginning to its final resolution based solely on the appeal of the individuals and on how they react to one another. The chapters alternate between ones developing the theoretical model and ones describing a familiar love story illustrating the predicted dynamics. The examples are mostly from their own published papers, but they have mentioned most of the relevant works of others even if only to dismiss them as oversimplified or unrealistic. Thus the book captures the state of the art in the mathematical modeling of romance and provides a unique basis for further development and application of the ideas.

The book is highly readable even for someone not steeped in the mathematical jargon of dynamical systems. In fact, it could be viewed as a primer on nonlinear dynamics with examples of attractors and bifurcations taken from familiar love stories. The dynamical processes are described in simple terms with a more rigorous but still easily readable mathematical treatment relegated to the appendix for those who want a deeper understanding of the mathematics and solution methods. There are no proofs, and the only mathematical prerequisite for understanding the models is familiarity with differential equations. All of the equations are provided, and the Euler method for solving them is described so that an interested reader could reproduce any of the results in the book and explore their dependence on parameters of the model or modify the equations to include additional effects or alternate assumptions.

The book begins with a simple two-variable linear model and explains the mathematical concept of an equilibrium. The addition of nonlinearities then gives rise to multistability and limit cycles. Random and periodic exogeneous stresses are then considered, described by stochastic differential equations and periodically-forced nonautonomous ODEs, respectively, which lead to quasi-periodicity and chaos even with only two variables. Three-variable systems are then considered in which one of the individuals has an extra emotional dimension, which can lead to quasi-periodicity and chaos even in the absence of exogenous effects. The book concludes with an introduction to love triangles where complex dynamics are the rule, but they describe in detail only one of the many possible models, leaving the door open for interesting further research. Along the way, they define and illustrate eigenvalues, bifurcations, catastrophes, frequency locking, Arnold tongues, intermittency, Lyapunov exponents, Poincaré sections, and much more.

For anyone who wants to research the mathematical modeling of romance or who wants a deeper understanding of the dynamics of interpersonal relationships or even who just wants to learn a bit more about nonlinear dynamics in an entertaining way, this book is highly recommended.

REFERENCES

Strogatz, S. H. (1994). *Nonlinear dynamics and chaos with applications to physics, biology, chemistry, and engineering*. Reading, MA: Addison-Wesley.

Gottman, J. M., Murray, J. D., Swanson, C. C., Tyson, R., & Swanson, K. R. (2002). *The mathematics of marriage*. Cambridge, MA: MIT Press.

--Julien Clinton Sprott
University of Wisconsin - Madison
E-mail: sprott@physics.wisc.edu