

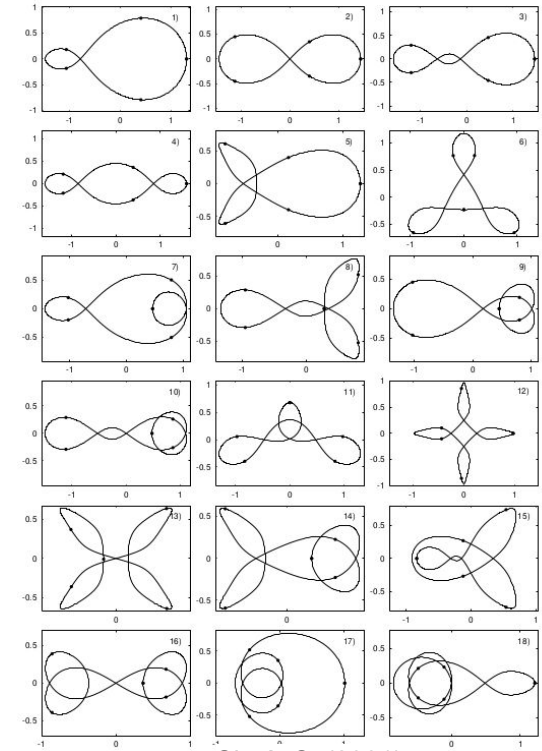
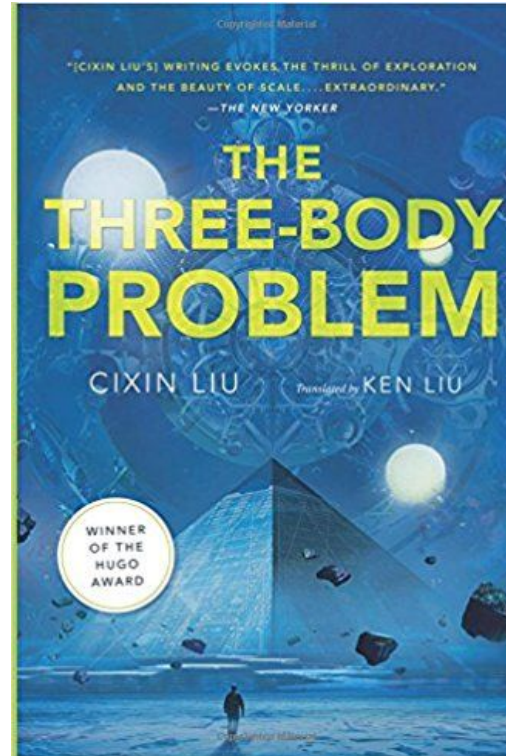
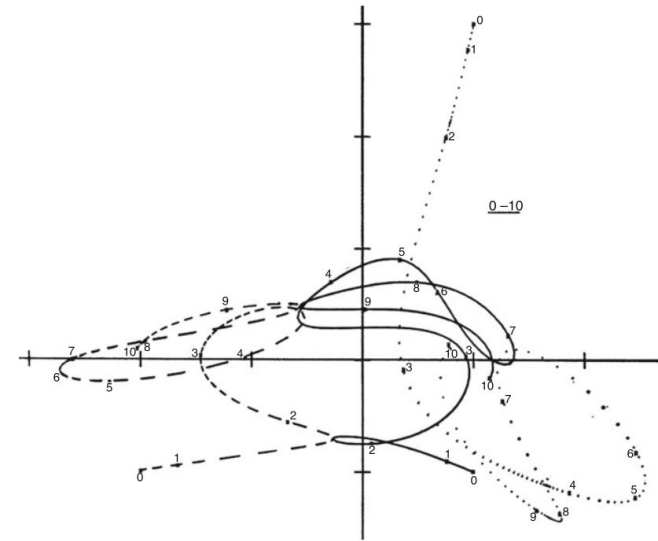


# The Three-body Problem in Geography

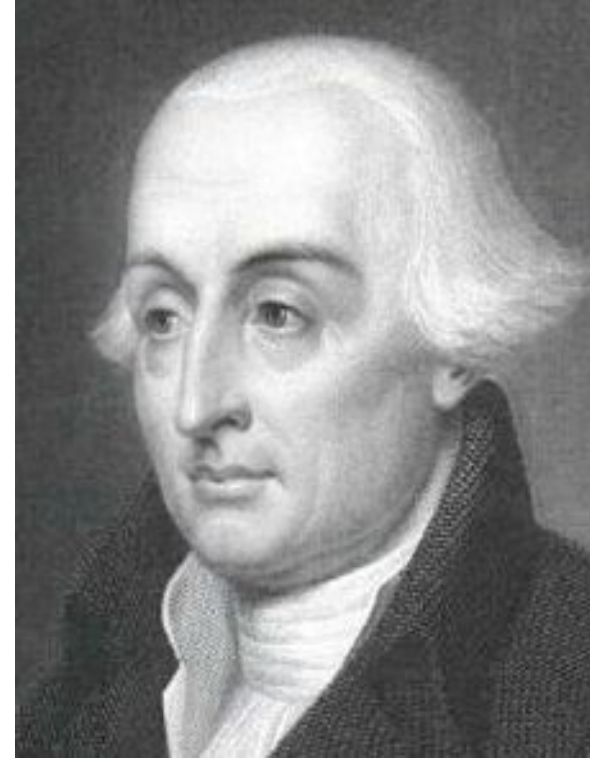
Rui Zhu

Department of Geography, UC Santa Barbara

# The Three-body Problem

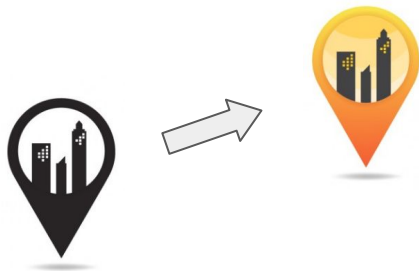


Simó, C. (2001)



# Spatial Interactions

- Gravity Model



# Beyond Spatial Interactions

- Co-location of places (points)
- Complex geographic fields
- Spatial networks
- ...



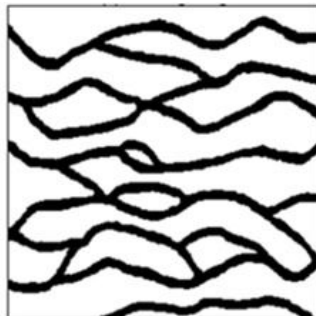
Grocery store



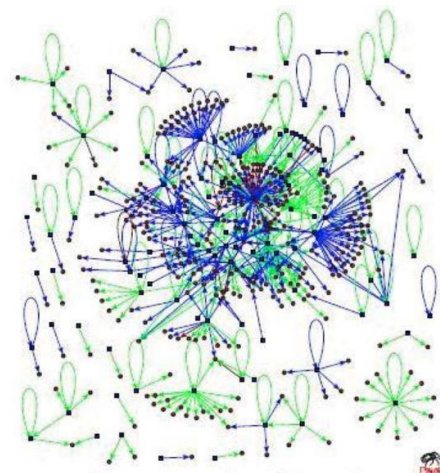
pharmacy



(a)



(b)





# Geo-Multipole

- Geo-dipole:

$$\langle x, x', Z, z(x, x') \rangle$$

- Geo-multipole

$$\langle x, t_N, Z, z(x, t_N) \rangle$$

where  $t_N = \{x_1, \dots, x_N\}$  are the  $N$  neighbors of  $x$ .





# Spatial Dependence

- Pair-based dependence

- Moran's I
- Geary's C
- Semivariogram
- Ripley's K
- .....

$$I = \frac{N}{\sum_i \sum_j \mathbf{w}_{ij}} \frac{\sum_i \sum_j \mathbf{w}_{ij} (X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}$$

- How about high-order dependence?

- Consider more than two locations **simultaneously**



# Open Questions

- What **extra information** could be extracted from **high-order spatial analysis**? Is it worth?
- What is the third, or even higher, order **stationarity**? How to interpret it?
- What kind of **new spatial statistical models** could be introduced?
- What is the relation with **deep neural network**? Is it a potential approach to facilitate **spatially-explicit neural network**? Can it be applied for **uncertainty analysis**?