

# Statistical mechanics for natural flocks of birds

William Bialek, Andrea Cavagna, Irene Giardina, Thierry Mora, Edmondo Silvestri, Massimiliano Viale, Aleksandra M Walczak

(Submitted on 4 Jul 2011)

Interactions among neighboring birds in a flock cause an alignment of their flight directions. We show that the minimally structured (maximum entropy) model consistent with these local correlations correctly predicts the propagation of order throughout entire flocks of starlings, with no free parameters. These models are mathematically equivalent to the Heisenberg model of magnetism, and define an "energy" for each configuration of flight directions in the flock. Comparing flocks of different densities, the range of interactions that contribute to the energy involves a fixed number of (topological) neighbors, rather than a fixed (metric) spatial range. Comparing flocks of different sizes, the model correctly accounts for the observed scale invariance of long ranged correlations among the fluctuations in flight direction.

Subjects: **Biological Physics (physics.bio-ph)**; Statistical Mechanics (cond-mat.stat-mech); Populations and Evolution (q-bio.PE)

Cite as: **arXiv:1107.0604 [physics.bio-ph]**  
(or **arXiv:1107.0604v1 [physics.bio-ph]** for this version)

## Submission history

From: Irene Giardina Dr [[view email](#)]

[v1] Mon, 4 Jul 2011 12:29:55 GMT (2365kb,D)

*Which authors of this paper are endorsers?*

## Download:

- [PDF](#)
- [Other formats](#)

## Current browse context:

physics.bio-ph

[< prev](#) | [next >](#)

[new](#) | [recent](#) | [1107](#)

## Change to browse by:

[cond-mat](#)

[cond-mat.stat-mech](#)

[physics](#)

[q-bio](#)

[q-bio.PE](#)

## References & Citations

- [NASA ADS](#)

## Bookmark([what is this?](#))



Science  
WISE