# Cosmic particle acceleration by shocks and turbulence in merging galaxy clusters

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Propositions accompanying the thesis:

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in merging galaxy clusters

1. The radio-emitting relativistic electrons in radio relics are accelerated by large-scale shocks that are generated during cluster mergers. (Chapter 2, 3, and 5)

2. The efficiency of particle acceleration by low-Mach-number shocks is still poorly known. (Chapter 2 and 3)

3. Radio haloes in merging galaxy clusters are associated with the turbulence that evolves after the passage of merger shocks. (Chapter 2, 4, and 5)

4. Shock compression alone of fossil electrons in the intra-cluster medium (ICM) is not sufficient to generate the observed brightness of extended radio emission in merging clusters of galaxies. (Chapter 4)

5. Double shocks on the opposite sides of the cluster centre may be common in major merging galaxy clusters. (Chapter 2, 3, 4, and 5)

6. High-resolution, multi-frequency observations including polarization measurements will significantly improve our understanding of particle acceleration mechanisms in extended radio emission from clusters of galaxies. (Chapter 4 and 5)

7. To unveil the truth, one needs to look through the object at the correct angle.

8. Re-observing to obtain high quality data is often a better strategy than continuing to work on low-quality data.

9. Multi-wavelength (e.g. radio, optical, X-ray) observations continue to be vital in unveiling the nature of astronomical phenomena.

10. Deeper observations sometimes require more detailed theoretical models to explain discrepancies.

11. "If you want to go fast, go alone. If you want to go far, go together" (African proverb). This is especially true in the present day field of radio astronomy.

12. Coffee breaks are important to generate research ideas.

13. It is mysterious that, despite the tremendous success of science in explaining nature, a large fraction of the world population is still religious.