In microscopic processes, it seems that time-reversal can be done and it can be useful in evaluation of some physics processes. For example scattering etc.

At macroscopic level (in the presence of dissipation), time-reversal obviously does not apply, we have a definitive direction of time, that is, entropy.

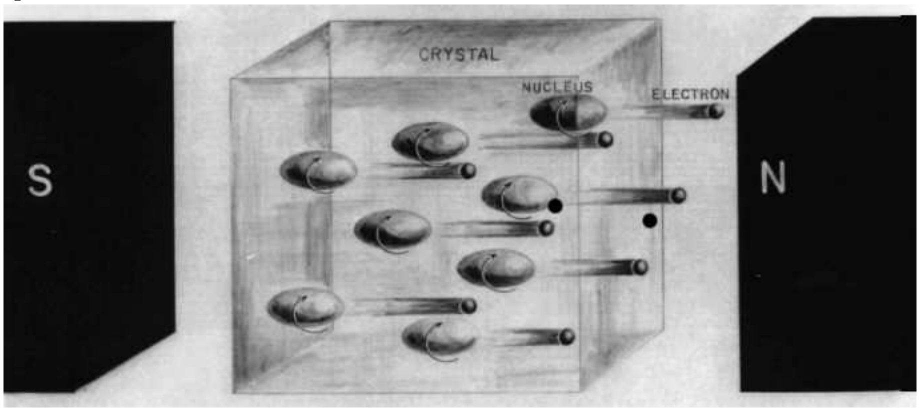
Unlike space-inversion, time-reversal *is not* a symmetry in a sense there would be a conserved quantity.

Violations of discrete symmetries

Parity non-conservation
Strong and electromagnetic interactions seem to obey discrete conservation laws.
Until 1956, parity conservation was considered as a fundamental conservation law.
Lee and Yang proposed that parity could be violated in *weak interactions.*
A year later this was measured in radioactive β-decay of ^{60}Cobalt isotope:

$$^{60}Co \ \rightarrow \ ^{60}Ni + e + 2\gamma$$

In the experiment Cobalt nuclei were cooled down to reduce the thermal motion and placed in a magnetic field that polarizes the nuclei according to spin.



Experiment show that more electrons are emitted "downwards", towards the northpole of the external magnetic field.
Wu got Nobel price for her experiment.
Experiment shows that the world *is not* left right symmetric *in weak interactions.*
This is still one of the major unsolved "mysteries" of physics.

CP-violation
Charge conjugation operator C changes all the charges like electromagnetic, quark flavors etc. in the system to opposites i.e. all particles are replaced by their antiparticles.

Yang and Lee already noticed that if P is violated then C can be as well.
How about the joint operation CP?
1964 Cronin and Fitch showed that CP can be violated in weak interactions as well
CP-violation was first measured in neutral Kaon decay.

$$K^0 = d\bar{s} \quad \neq \quad \overline{K^0} = \bar{d}s$$

Notice, unlike $\pi^0 = \overline{\pi^0}$, neutral Kaon and anti Kaon are distinct particles that can, however, turn into each other via weak interaction.
It was first noticed (actually for K^+) that there are 2 similar particles

$$\theta \to \pi\pi \quad \text{and} \quad \tau \to \pi\pi\pi$$

with different parities, since P(π)=-1 and parity is multiplicative.
Obviously trivial identification $\theta = K^0$ and $\tau = \overline{K^0}$ is nonsense.
Since weak interaction can mix the Kaon and anti Kaon, the Hamiltonian reads

$$H = \begin{pmatrix} H_0 & \Delta \\ \Delta & H_0 \end{pmatrix}$$

In which the off diagonal terms are responsible for the $K^0 \leftrightarrow \overline{K^0}$ oscillation.
Note $\langle N_{K^0} \rangle = N_{K^0} + N_{\overline{K^0}}$
Diagonalizing we find the parity eigenstates. We define

$$K_1 = a_1 K^0 + a_2 \overline{K^0} \quad \text{and} \quad K_2 = b_1 K^0 - b_2 \overline{K^0}$$

which are parity eigenstates corresponding to the eigenvalues ± 1.
Now we have $K_S \equiv K_1 \to \pi\pi$ is shortlived while $K_L \equiv K_2 \to \pi\pi\pi$ lives much longer.
In order to keep us on our toes, nature decided differently, experiments show that

$$K_S = K_1 + \epsilon K_2 \quad \text{and} \quad K_L = K_2 + \epsilon K_1$$

i.e. there is small CP-violation ($\sim 10^{-5}$ %) in the neutral Kaon decay modes

$$K_S \to \pi\pi\pi \quad ; \quad K_L \to \pi\pi$$

Is this connected to the matter/antimatter symmetry in the universe?
Something else?
Note Any acceptable (read: standard model compatible) (field)theory is CPT-invariant by construction.
It follows that in case of CP-violation, T is violated as well.

First place to search articles
Most of the "mammuths" and uptodate physics articles (preprints and direct links to the journal archives)
http://www.slac.stanford.edu/spires/
or
http://www.arxiv.org/
but spires actually scans the arXiv as well...