Irreversible Processes Encyclopedia Article

Irreversible Processes

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Irreversible Processes

On a small enough scale, virtually all of the laws of physics seem to be symmetrical in time. That is, when dealing with small enough objects--for instance fundamental particles--there is no preferential direction in which time flows. (Note that this is not absolutely true: recent experiments have shown that time asymmetry can be broken at the fundamental particle level, but only extremely rarely.)

On the macroscopic scale, however, we clearly observe a marked time asymmetry in the laws of nature; beyond the very smallest scale interactions, time always seems to flow in one direction. There are countless examples of the directionality of the flow of time. We observe traces of past occurrences all around us: footprints, photographs, memories, last night's dirty dishes, but we never stumble across the debris left behind by future events.

It seems a bit puzzling that laws of nature that have no built-in time asymmetry give rise to a world in which time clearly flows in one direction only, from past to future. The source of the asymmetry lies in the second law of **thermodynamics**, which states that any closed system tends to evolve so that its **entropy**, or disorder, increases. Thus, even though the laws that govern the behavior of individual bodies--for instance **Maxwell's equations**, Newton's laws, and the Schrödinger's equation--do not define a preferred direction in time, a system made up of a large number of bodies will evolve irreversibly in a way that leads to increased disorder or entropy.

One notable example of an irreversible process is the spontaneous flow of **heat**. The **second law of thermodynamics** requires that heat always flow from warmer to colder bodies, while forbidding it from flowing in the other direction. This is one of the "one-way" processes that define an "arrow of time" for the **universe**.

Other common irreversible processes are "mixing" processes. A drop of red dye will spontaneously diffuse throughout a cup of water, but the process will never occur in reverse, with all of the pre-mixed red dye spontaneously coalescing in a single drop suspended in the water. Again, this is due to the fact that the entropy or disorder of the well-mixed system is much greater than that of the drop of dye suspended in clear water.