

How different would our Universe look with the addition of extra particles and forces beyond what we know? We already have ample gravitational evidence for at least one invisible component of matter that has properties unlike anything we have previously discovered. This "dark matter" is often assumed to be made of a single species of relatively inert particles but there is a much richer range of possibilities, including scenarios where dark matter is part of a "dark sector" including other auxiliary particles and forces. If there are dark forces affecting the distribution of dark matter in our Universe, then that distribution will gravitationally affect the visible matter that we can see. In this colloquium I will show how this gravitational footprint can reveal the behavior and properties of dark sectors. I will emphasize the constraining power of diverse astrophysical systems for these purposes, including the Sun, the local Milky Way, nearby dwarf galaxies, distant galaxies and galaxy clusters, large-scale cosmological structure, and the cosmic microwave background.