Gravitational lensing is a phenomenon which was predicted by **Albert Einstein’s in theory of general relativity** in the year 1915. where the gravitational field of massive objects Like Galaxies or Clusters bends the path of light rays passing by. This bending of light can produce distortion in the images of background objects, known as source, as observed from Earth.

Newtonian physics also predicts the bending of light, but only half of that predicted by general relativity. In 1912, Einstein speculated that an observer could see multiple images of a single light source, if the light were deflected around a mass.

This effect would make the mass act as a kind of gravitational lens. The mathematics showed that any massive celestial object can bend passing light rays in the same way that a glass lens bends light in a telescope or microscope. This result played a key role in the experimental proof of Einstein's theory.

The distortion of light can create multiple images, arcs, or even complete rings of the background object known as Einstein’s rings.

Just like normal matter Dark matter can also form gravitational lens, even though they don’t emit, absorb or reflect electromagnetic radiation.

**Detection of Dark Matter Substructures(DMS)**

These are smaller clumps or concentrations of dark matter within Galaxies or clusters, they present a difficult challenge to detect due to their low luminosity and lack of interaction with light. However Gravitational lensing can be used to indirectly identify these substructures.

One of the methods to identify DMS is to analyse the fine scale distortion in the lensed images. DMS, such as small clumps or steams, can perturb the smooth gravitational potential of lensing Galaxies or Clusters. These perturbations can create small-scale deviations known as micro-lensing. In simple words it occurs when a compact DMS passes directly in front of a background star, temporarily amplifying its brightness. The transient increase in brightness can be observed and used to identify presence of Dark Matter Substructure.

Sounds like a promising method, however it comes with its own set of challenges.

Firstly, the alignment of substructure must be precise with the background star so that the produced microlensing can be observable, this alone make detection make rare. Furthermore, the duration and amplitude of microlensing depends upon the mass and distance of substructure, making it more challenging to distinguish DMS events from other astrophysical phenomena.

Another method involves studying statistics of Strong Gravitational lensing systems. Strong gravitational lensing occurs when the alignment btw source, Lense and observer is nearly perfect, leading to formation of multiple, highly distorted images of source. DMS inside galaxies can add even more complexities to the lensing configuration, resulting in deviations from expected properties. By comparing expected strong lensing with observed strong lensing astronomers can identify traces of DMS and constrain their properties.

**Challenges to Detect DMS:**

Detection of DMS with Gravitational lensing faces several challenges. One of the challenges is the degeneracy between DMS and other sources of mass, such as star or compact objects, which can produce similar lensing effects. Differentiating between can be difficult and requires complicated calculating techniques.

Another challenge is the limited resolution and sensitivity of our current observation instruments. DMS are typically small and faint, making them difficult to detect directly. To overcome this astronomer often rely on simulations to generate mock lensing data and explore the detectability of DMS