Reg. No: 2023/51/B/ST9/00943; Principal Investigator: dr hab. Vincenzo Salzano

Can a slime mold help us alleviate cosmological tensions?

There is a widespread belief in public opinion that 'science' is synonymous with "certainty" and "precision". From a scientific point of view, we are living in a historical moment where these two concepts do not help us, not at all.

On the one hand, in this era of *"cosmological precision"*, we have been able to build a model of how the Universe has formed and evolved, which is able to explain most of the things that happen in it. *"Most"* of them, not all, which is why we call it a *consensus* model. But it can only do that by assuming that, apart from ourselves and the small atomic particles that make up the world around us, about 95% of the matter and energy in the Universe comes in unknown "dark" forms, the famous dark matter and dark energy. Their nature, origin and fate are still a mystery. The only thing we know is that they are out there, because we can measure them, indirectly.

On the other hand, the precision we have achieved in cosmological observations in the recent past has led us directly into an era of "cosmological tension": we have many measurements, each very precise, that do not agree with each other, creating cracks in our consensus cosmological model. And we don't (yet) know why.

In this project we will explore a new methodology to compare different theoretical approaches and develop a tool, completely independent of gravitational theory, that will be able to reconstruct the cosmic web and resolve, or at least mitigate, these cosmological tensions, confirming or refuting our vision of the Universe in a model-independent way.

We will start from the behaviour of a system of a completely different nature, a biological organism, the *Physarum polycephalum*, a slime mould, one of those yellowish creatures that grow on your badly preserved food.

Why do we do this? Because while exploring space in search of food, the *Physarum* creates characteristic networks, with "veins" of the organism connecting all the positions where the food is located. These networks are not random, but are dictated by chemical and physical laws.

The most innovative aspect of our work is that we will use the behaviour of this organism, we will simulate the way it moves and we will compare its web with the cosmic web. We know that there are "visual" similarities. But can we use such gravity-independent webs to understand gravity?

We will establish such a method by running several simulations to create a *Physarum* Universe, a web created using the motion of the *Physarum*, and we will compare it with cosmological simulations based on many cosmological models based on General Relativity. Finally, we will confront this Universe with the real Universe, using the most up-to-date data we have collected so far on the cosmic web, made up of millions of galaxies.

The added value of this project won't be limited to cosmology. The work on the *Physarum* will be highly beneficial as it can be used in various applications beyond cosmology, such as in urban areas to optimise traffic flow and public transport systems; in logistics and supply chain management to reduce operational costs and environmental impact; in biology to understand how cells communicate.

Our project will provide a deeper insight into the analogies between systems from two completely different and seemingly unrelated regimes, the microscopic scales of biological nature and the vast large scales of our Universe. Such analogies are often emphasised, and physicists are usually fond of such correspondences because of their love of symmetries and the unification of all physical laws into a single global picture. But in this project we will quantify such analogies mathematically and numerically, and extract the basis for something more solid than mere philosophical similarities.