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Lecture Reviewed
Given to the **Worthing Astronomical Society** on the **19th September 2018**

Review by **Graham Boots**

Title "**Probing the dark universe with a trio of extraordinary telescopes"**

SUMMARY OF MAIN POINTS by **Dr David Bacon**

As we examine larger and larger distances in the Universe, we discover that the behaviour of objects is dominated by several invisible entities:

- Gravity; in the Solar System, we can almost get away with Newton's law of gravity, but other objects (e.g. black holes) and behaviours (e.g. light bending) need Einstein's theory of gravity.

- Dark Matter; there is much more gravity acting (e.g. in galaxies, in clusters of galaxies) than we'd expect from the visible material alone. We need about 5 times more material to be present, in a form which doesn't emit or absorb light.

- Dark Energy; the galaxies are moving away from each other, faster and faster - what is the cause of this? Whatever it is, we call it dark energy.

The overall picture is of a cosmic web of dark matter, which has formed due to the way that gravity draws material together. Then the galaxies are like visible dew drops on the web. The whole web is expanding under the influence of dark energy.

New telescopes are being built which will enable precise study of these strange features of the Universe. The Euclid space telescope, the Large Synoptic Survey Telescope (optical), and the Square Kilometre Array (radio) will measure properties of the dark Universe to percent level accuracy.

We're in a peculiar situation: we have fantastic data and evidence for the dark Universe, but do not understand its nature. Hopefully our theoretical understanding will advance at the same rate as our measurements in the next decade!

REVIEW by **Graham Boots** member of the Worthing Astronomical Society.

David began by explaining the dark universe are items that do not glow.

The dark energy survey uses three types of telescopes. The Euclid space telescope is a visible to near-infrared space telescope currently under development by the European Space Agency (ESA) and Euclid Consortium. The objective of the Euclid mission is to better understand dark energy and dark matter by accurately measuring the acceleration of the universe. To achieve this, the Korsch-type telescope will measure the shapes of galaxies at varying distances from Earth and investigate the relationship between distance and redshift. Dark energy is generally accepted as contributing to the increased acceleration of the expanding universe, so understanding this relationship. This telescope has been 66 months in the planning and is expected to image half the whole sky or about 15,000 square degrees.

The second telescope is known as the LSST Large SYNOP Telescope. The Large Synoptic Survey Telescope is a wide field survey reflecting telescope with an 8.4 primary mirror currently under construction that will photograph the entire available sky every few nights. It is expected to give observations that provide a broad view of a subject at a particular time, and will provide up to 50 pela bytes of data revealing up to two billion objects.

The third telescope is a radio telescope known as the Square Kilo-meter Array. The Square Kilometre Array (SKA) is a large multi radio telescope project aimed to be built in Australia and South Africa. If built, it would have a total collecting area of approximately one square kilo-meter and consist of thousands of dishes. At present it has just 64 dishes.

In our close environment we have our Galaxy the Milky Way, the Local Group of Galaxies numbering about 40 galaxies, most of them dwarf galaxies. Outward still, the clump of matter known as the LANIAKEA SUPER CLUSTER which we are within this great spread stretching out to a super cluster of galaxies measuring three hundred million light years across.

Thanks to strong gravitational lensing, today we can see out across our universe to a distance of around four billion light years and we are attempting to survey all this we see.

It is calculated that we need to find five times more mass than we observe to provide the amount of gravity necessary to hold these structures together.

When we survey the universe on a very large scale we find there are big gaps with hardly any mass in them while large long filaments of mass form.

There is a survey in Chile called CT10 covering a quarter of the sky and is said to be able to record eight billion light years deep.

The various sky surveys will enable us to calculate where and how much dark energy there is and how it is distributed. Weak Gravitational Lensing will enable us to work out what matter is distributed in between objects.

There have been many investigations to discover the makeup of our universe. So far the most accurate figures we have are baryonic matter, that which we can see and touch 4.9%. While the strange remainder are dark matter 26.8%, which is influenced only by gravity and dark energy about which we know next to nothing and yet is responsible for 68.3% of our universe.

Dr. David Bacon is a leading scholar in seeking to understand these matters and he shares his time with fellow scholars while using the most up to date equipment available to them. He and his colleagues realize they live and work in an exciting and thrilling age of discovery.