Outline

In the scientific community, dark matter is defined to be any non-luminous objects that does not absorb or reflect light. Dark matter is significant to us as it can determine the future of the universe.

Thesis: There is a lot of evidence to verify the existence of dark matter, but although the theory of dark matter is the most complete to explain the observations we have, there are many other theories, but which require the alterations of many fundamental physics laws.

I. With current observations, there are deviations and counter examples of current physics laws. The existence of extra matter and energy can account for the deviations, so they have been postulated.
   A. Big Bang Theory
      1. expansion or contraction of the universe
      2. luminous material currently observed throughout the universe does not amount to nearly enough mass to halt the expansion
      3. dark matter might supply the missing gravity necessary to halt the universe's expansion
      4. to account for the observed acceleration, physicists postulated dark energy
         a) helps push things apart
         b) since energy and matter are interchangeable, some of the universe's dark matter may thus turn out to be energy
   B. gravity
      1. velocities of many stars in the galaxy do not agree with calculated values based on the assumption that the visible material constitute all or even most of their mass
         a) indicate the presence of massive halos of dark matter
II. What is dark matter?
   A. supermassive black holes exist at centers of galaxies
      1. observations of x-ray bursts confirmed the presence of a large black hole in Milky Way
      2. they supply invisible mass and count as dark matter
   B. non-luminous brown dwarfs (MACHOs [massive compact halo objects])
      1. dim blobs of gas
      2. have been detected using gravitational lensing
      3. not in sufficient numbers to account for the amount of dark matter that is believed to exist
   C. neutrinos
      1. pervade the universe in very great numbers and have a small mass
      2. calculations (2002) - neutrinos can only account for at most ⅕ of dark matter
      3. only sterile neutrinos could possibly make up dark matter
         a) sterile = those formed immediately after the Big Bang
   D. WIMPs (weakly interacting massive particles)
      1. permeate the space around the galaxies, and held together in clouds by gravity
   E. MACHOs
      1. black holes, neutron stars, brown dwarfs, various undetected planets

F. non baryonic dark matter
    1. baryonic - composed of baryons (e.g. protons, neutrons)
    2. can emit light and is not composed of baryons
    3. some think that they make up most of dark matter

III. Many experiments are being conducted to search for dark matter (shows attempts to find evidence for dark matter)
    A. large chunks of metal held in underground mines
        1. D.M. interact very weakly with normal matter
        2. enough time and patience should eventually witness one bump into a particle of normal matter
    B. indirect searches in space
        1. evidence of D.M. decaying, annihilating, or being eaten up by black holes
    C. colliders (e.g. LHC) could conceivably produce dark matter particles
        1. technically invisible, but could be identified from the amounts of the missing energy that they carry out of the detectors
    D. LHC having the best chance of creating and detecting low mass dark matter (10-100 GeV)
    E. direct detection experiments e.g. XENON100, and the Ice Cube Neutrino Observatory more sensitive to high mass candidates

IV. Many experiments and observations conducted to search for dark matter show good results.
    A. A 7 keV sterile neutrino
        1. 2 independent research groups confirm a new x-ray emission line associated with galaxies at an energy of just over 3.5 keV
            a) data showed unexplained emission lines at energy about 3.55 keV, as did analyses based on all or various parts of the x-ray cluster data
                (1) no x-ray line associated with conventional physics appears at that energy
                (2) similar analysis of the Perseus and Virgo galactic clusters and found same unknown line with same energy and strength
            b) second independent study saw emission at 3.52 keV for Perseus and Andromeda (conclusions were essentially identical)
        2. energy and location of the signal is consistent with the decay of a form of dark matter (a 7.1 keV sterile neutrino turning into a photon and an ordinary neutrino)
            a) sterile neutrino
                (1) neutrinos not included in the Standard Model of Particle Physics
                (2) do not undergo weak interactions
                (3) lack of interaction makes them difficult to create (produced in the early stage of the Universe, as the Universe cools after the Big Bang)
    B. 35 GeV WIMP
        1. new study of gamma ray emissions from the central regions of the Milky Way
            a) strong evidence that observations include a signature of dark matter in the form of WIMPs

        b) after accounting for known gamma ray background sources, an additional source of GeV gamma rays is required to match observations
        c) the presence of this excess is claimed to have a statistical significance of 40 sigma (5 is usually considered experimental proof in particle physics)
    2. the study reveals that the gamma ray excess is roughly spherically symmetric
        a) centered on our central supermassive black hole
    3. spectrum of the excess matches closely that expected from a massive dark matter WIMP
        a) a 35 GeV WIMP annihilating into a bottom quark-antiquark pair, which themselves eventually decay into components including gamma rays
        b) although strongly suggestive, not sufficiently convincing
        c) better proof if similar signals are seen in dwarf galaxies
            (1) dwarf galaxies are among the objects most dominated by dark matter
    4. search in dwarf galaxies made, and small excess of gamma rays found but with a statistical significance of only 2.5 sigma

V. There are other possibilities and theories in place of dark matter
    A. {other theories}

VI. Conclusion
    A. Although there are many experiments that indirectly confirm the existence of dark matter, some experiments still do not show good results as expected, and other theories are still not refuted. More evidence will be needed before everyone can agree on the existence of dark matter, and maybe a direct result will be more convincing than indirect results.