June Glichrist introduced Dr Bill Ward from the University of West Scotland talking about:

**Modern Meteor Astronomy and Developments in Meteor Spectroscopy**

Bill started by explaining meteor terminology as it is quite often mixed up in media reports and even sometimes by astronomers! The meteoroid is the actual particle, the meteor the visible phenomena and the meteorite is the recovered particle which has landed on the ground. The vast majority are small grains travelling between 11 and 72 km per second as they enter the earth’s atmosphere. Ordinarily the visual magnitude is 0 to 5 though of course very bright fire balls are occasionally observed. Meteors have been observed since antiquity but the modern theories were first proposed in the 18th Century by Brande and Benzenberg in Germany in 1798 carrying out observations to estimate the heights of meteors. Choosing suitable separate locations and timing their observations and identifying location in the sky of meteors allowed them to make reasonable estimates of the heights of meteors. Bill reproduced this experiment using the baseline between Beith and Kilwinning and making observations of the 2007 Ursids. Relatively straightforward triangulation and trigonometry gave a meteor height of 109 km. The 1930s to 1960s saw the development of accurate professional experiments and theories of meteors. There now exists a global network of video cameras which capture and analyse meteors using modern software techniques.

Visual observing has become less popular but still has scientific value. The use of film cameras was tedious and difficult resulting in few captures of meteors and problems with film processing when sent to commercial labs used to dealing with normal daytime subjects.

The DSLR camera resolved these difficulties as there is no film to process and large amounts of data can be captured and analysed immediately. A simple interval timer can be used and with multiple cameras pointing at the sky it is relatively straightforward now to capture meteors at least during showers. These cameras can be left while the astronomer sleeps if they are weather proofed!

Radio data provide by amateurs can be a valuable weather proof supplement to automated video recordings. Radio data can also work round the clock. However, video techniques are now the primary source of meteor data.

Video spectroscopy is now possible at reasonable cost and useful resolutions. Bright fireballs when analysed spectroscopically can provide a wealth of data. It is possible to determine what the meteor is made of.

There is still a place scientifically for visual observing since there is a need to calibrate the video zenith hourly rate. Bill then showed images of old film cameras which he had used for meteor photography. He had tried for twenty years to capture spectra using film cameras with littles success. The film lab on one occasion had obliterated the streaks of light on the film as it was deemed to be a defect! Bill moved on to using multiple DSLRS with intervalometers to captures meteors and described how useful bubble wrap could be in providing insulation to prevent ice or moisture forming on the cameras.

Bill described the use of rotating shutters on cameras can be used to provide up to 60 breaks per second on exposures. This is useful to determine the duration of the meteor and possibly the speed. Spectral analysis may reveal a minimum speed since forbidden wavelengths may only be emitted above certain speeds. Bill pointed out that not all meteor trails are for real as the sky is now full of satellites. If you are using a rotating shutter then a satellite trail will be unchopped as it is travelling much slower than a meteor.

The mechanism for radio meteor observing was briefly described. The air surrounding the ablation of the meteor is ionised and therefor the free electrons will reflect radio waves. The Graves space radar in France illuminates the sky over southern France to detect space junk and is a very powerful radio source, the back lobe illuminates meteors which can be detected in the UK by suitable antennas and radio receivers. This operates at 2 metres or 144MHz. Meanwhile the BAA has set up a radio beacon in Nottinghamshire which although much lower power operates on an optimal frequency of 50MHz which will provide reflections from meteor ionisation trails detectable by suitable systems throughout the UK.

Radio is very suitable for 24 hours observing and is not affected by cloud and rain. Bernard Lovell set up a meteor observatory at Jodrell Bank in the form of a radar system and this system detected and confirmed the existence of daytime meteor showers.

Suitable video cameras became available in the late 90’s early 2000’s. The Watec security cameras were found to be good at meteor observing. Bill employed a Watec camera for the first time on the 2006 Perseids with a resolution of 320 x 240 pixels. UFO captures and analysis software has proven to be very effective at reducing the video capture data. Currently millions of meteors have been observed by these cameras, hundreds of thousands of orbits have been measured and hundreds of thousands of light curves gathered. The global network of automated video cameras continues to grow in size. Bill showed an image of Perseid ground tracks followed by a plot of the radiant determined by these numerous ground tracks.

Diffraction gratings are now available for modest amounts of money and Bill showed spectra gathered from a 2015 suspected Taurid fireball. The entire spectrum was caught showing strong Calcium, Magnesium and Sodium lines. The actual spectra were shown as well as graphical spectra produced by software which can build up a graph from the pixel data. Absorption lines can even be seen on these spectra. The spectra actually evolve over each frame so the transitions at different times informs us about temperature and the ablation mechanism. The use of a global shutter camera which exposes the whole sensor in one go has detected the formation of oxides during ablation The resolution of modern cameras allows fairly detailed spectra to be produced with 0.25 nm / pixel resolution.

Bill detected a suspected Coma Berenecid displaying forbidden oxygen emission thus indicating the meteor moving fast and high. A speed of at least 64 km per second.

The original classification system for meteors was proposed by Millman and McKinlay in 1957 and their book on radio meteor observing and engineering is still a reference book today. The suggested four classes Y, X, Z and W, a rolling scheme based on lines identified in data but there is not enough data to carry on with this scheme.

A new scheme has been proposed by Bill with A, B, C and X as the four categories. A being rocky material, B being pure iron, C being strong sodium lines with weak iron lines and X being partial or unresolved spectral lines. So, looking again at emission lines:

A Calcium, Magnesium, Sodium and Silicon which is associated with rocky material

B Pure Iron

C Sodium and Iron lines.

A brief description of the major global video monitoring camera networks was given which are Nematode and Global Meteor Network which employ automated systems send data to central servers for analysis. At the moment it is possible to by a system for a few hundred euros which can be provided set up and ready to go.

 A question-and-answer session followed which expanded on some points made in the talk.

Sporadic meteor analysis may not match to a parent body since the orbit of sporadics diverges from any parent body over time. While particles break away from a Comet will initially have the same orbit, they have slightly varying velocities and over time form their own orbits. Tom Lloyd Evans deceased past member of the society and professional astronomer wrote a paper many years ago about meteor spectra. When it is known that the meteor is associated with a comet it will primarily be type A spectra. Iron spectra tend to be from sporadics are in the ecliptic plane and probably asteroidal. The expected collection rate for micrometeorites is of the order 1 particle per metre squared per year. Man made materials falling from space tend not to be as pure as real meteorites. The image of spectra has to be straightened, needs careful calibration before assigning wavelengths to colour and then finally matching an element to the particular line. Generally, a strong sodium line is used as a calibration reference then distances to other lines are calibrated then as more lines are added the accuracy increases until the spectrum has been fitted.

A vote of thanks was given and then refreshments were served and members were able to discuss the talk informally with Bill Ward.