A brief introduction to narrowbanding

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Studies of star formation regions of our galaxy have been part of the evolution of our knowledge of the universe. Star formation regions are usually determined by the measurement of emission lines because stars ionize the gases surrounding them. One of the most common emission lines studied has been the $H\alpha$ ($656.3nm$) mainly due to it is directly proportional to the number of ionizing photons from massive stars. Narrowband imaging can show details of ionizing regions, when analysing scientific data, helping in the identification of the different regions in a nebula.

Amateur astrophotographers use narrowband filters as a technique to reduce the brightness of the Moon or to deal with the ever increasing light pollution of our night sky. The main objective of this paper is to present the most common emission lines used in amateur narrowband astrophotography together with the different kind of deep sky objects associated with these bands.

1 Most used line emission

Herewith we enclose a brief survey of most common emission lines and their main characteristics. In the following image taken from [1] it is shown each of those lines at their corresponding wavelenght.

Beginning from the **Sulfur** double emission line (**[S II]**), at wavelenghts of $671.6nm$ and $673.1nm$ corresponding to the red part of the visible spectrum[1]. It is represented between brackets because its a forbidden line[2]). [SII] is commonly observed in nebulae and, it has been found that the ratio [SII]/$H\alpha$ tends to increase as absolute $H\alpha$ intensities decrease.

Nitrogen double line emission (**[NII]**) at wavelenghts of $654.8nm$ and $658.3nm$ is also in the red part of the visible spectrum. It is very near to $H\alpha$ emission line ($653.6nm$) and most $H\alpha$ amateur astronomy filters pass the [NII] line. As well

[1] is the portion of the electromagnetic spectrum that is visible to the human eye from about 380 to 750 nm

[2] Forbidden line is not one that is actually 'forbidden'; it's just an emission line, or state of atom excitation, that occurs in these nebulae, but is impossible, at the present time, to duplicate in laboratories located here on Earth

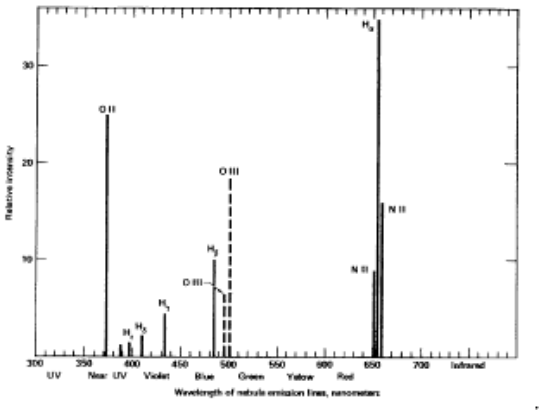

Figure 1: Most common emission lines

as the [SII], it observes the same trend to increase as the $H\alpha$ intensity decrease [2].

The most common emission line in star forming regions is the **Hydrogen alpha** ($H\alpha$) at $653.6nm$, corresponding at the red part of the visible spectrum. In narrowband astrophotography is the most used filter as it is very common in emission nebulae (see fig. 2).

Figure 2: The Heart nebula in Casiopeia in $H\alpha$.

Another common emission line in nebula is the double ionized **Oxigen** (**[OIII]**) at $495.9nm$ and $500.9nm$. It is locatef just at the center of the electromagnetic spectrum corresponding with the green. It is very common in

planetary nebulae and supernova remnants.

$H\beta$ emission line at wavelenght of $486.1nm$ is in the blue part of the spectrum. Most of the $H\alpha$ emission detected arise from hydrogen recombination and from physics the ratio of $H\alpha$ to $H\beta$ is about 3:1, thus it is also a common emission line. The major problem arises due to the presence of interstellar dusts that absorbs more blue light, thus it is not as observed as $H\alpha$ emission.

2 Selecting the objects for narrowband imaging

Usually, most common narrowband images are taken through $H\alpha$, SII and $OIII$ filters. There are a lot of deep sky objects suitable for narrowbanding imaging. When selecting a possible target it is important to know if it emits in the wavelenght corresponding with the bandpass of the filter. The objects most suitable for this kind of astrophotography are emission nebulae, planetary nebulae and supernova remnants.

Emission nebulae

Emission nebulae are glowing clouds of interstellar gas excited by energetic radiation of nearby hot stars. The material between the stars is rich in the most abundant element, hydrogen, so this element became ionized and glows with red hue. In these objects there are also usually traces of oxygen and sulfur.

The list of emission nebula that are good targets for narrowband imaging is quite large. Can be cited the Soul and Heart nebulae (IC 1848 and IC 1805 respectively, the pacman nebula (NGC 281) at Casiopeia constallation; the NorteamÃľrica and Pelican nebulae (NGC 7000 and NGC 5070) at Cignus the swan; the Rosette nebula (NGC 2237) at the constellation of Monoceros; the Eagle nebula (M16) at Serpens Cauda; the Swan nebula (M17) at Sagittarius among others.

Planetary nebulae

Planetary nebulae are the remnants of the external layers of sun-like star. In other words, what we are seeing is the future of our sun. When a sun-like star have burned all the hydrogen to helium in its core, becomes a red giant burning also the carbon to oxygen in the nuclear reactions. After that, the outer layers expand and the instabilities cause the ejection of a significant part of the mass star. In the core, remains only a small central star.

Most stars emit in continuous spectra, but for stars that have aged to the planetary nebula stage, their spectra have been altered dur to the higher temperature. As a consequence, the emission spectra of these objects consist of discrete emission lines. The most common lines in planetary nebula are shown in table 1.

wavelenght [nm]	ion	Observations
372.7	O II	Forbidden line
434.0	H I	$H\gamma$ (0.4 of $H\beta$)
486.1	H I	$H\beta$ (one third of $H\alpha$)
495.9	O III	Forbidden (one third of 500.7nm)
500.7	O III	Forbidden(usually the strongest)
654.8	N II	Forbidden (one third of 658.4nm)
656.3	H I	$H\alpha$
658.4	N II	Forbidden line

Table 1: Emission lines for most planetary nebulae

Among the most suitable planetary nebula for narrowbanding imaging are the Dumbbell nebula (M27), the helix nebula (NGC 7293), the bug nebula (NGC 6302), the Crescent nebula (NGC6888) among others.

Supernova remnant

When a star significantly more massive than our Sun runs out of fuel, it collapses and blows itself apart in a catastrophic supernova explosion. The exploding star sweeps out a huge bubble in its surroundings. This glowing, brightly colored shell of gas forms a nebula that astronomers call a "supernova remnant."

The most famous supernova remnant is the Crab Nebula in Taurus (M1). In the outer regions there are many emission lines including the red glow from hydrogen. In other supernova remnants, such as the Veil in Cygnus (Cygnus Loop) only the emission lines in the wake of the expanding shock wave are visible. Among the emission lines observed are oxygen, sulfur and hydrogen.

It is importamnt to remark that galaxies, globular and open clusters and reflexion nebulae emit in continuos spectra, thus they are no suitable for narrowband imaging.

References

[1] Brazell, O. . Nebular filters in deep sky astronomy. *Journal of the British Astronomical Association*, vol.104, no.5, p.231-235. 1994

[2] Haffner and Reynolds and Tufte. WHAM Observations of HÎś, [S II], and [N II] toward the Orion and Perseus Arms: Probing the Physical Conditions of the Warm Ionized Medium. *The astrophysical Journal.* 525, L21, 1999.