

From the Web Site of Robert John Morton

Short-Wave Radio: The Water Hole Band

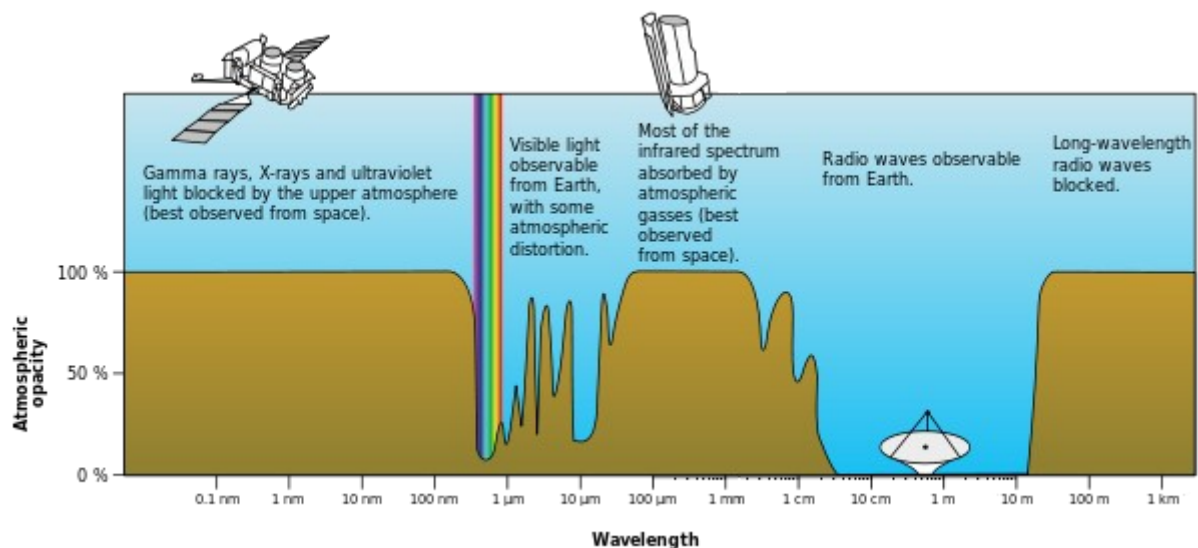
Devotees to the search for extraterrestrial intelligence suppose that this band is the one small stretch of the electromagnetic spectrum within which alien intelligences are most likely to attempt to communicate with other intelligent beings such as ourselves.

The immense size of the universe makes physical contact with alien intelligences beyond our solar system fundamentally impractical. It would take many human lifetimes even to reach stars within our closest neighbourhood. The only practical option is radio, and even that is very limited. There are, however, two major obstacles to interstellar radio communication.

Atmospheric Barrier

The first obstacle is the Earth's atmosphere. This blocks radio signals - one way or another - over most of the electromagnetic spectrum. Notwithstanding, there are certain gaps or "windows" through which the atmosphere allows radiation, of certain limited ranges of wavelength, to pass.

We can see the sun, moon and stars. This means that the atmosphere must allow waves within our visible range to pass through, although not without at least some degree of attenuation. The wavelength windows within the Earth's atmosphere are shown for the whole electromagnetic spectrum in the excellent NASA illustration below.



The illustration shows that the Earth's atmosphere is completely transparent only for electromagnetic waves from 3 cm to 12 metres in length. This corresponds to radio frequencies from 10 GHz down to 25 MHz.

Waves shorter than 3 cm become absorbed by the atmosphere. To electromagnetic waves from 3 cm downwards the atmosphere thus becomes increasingly foggy, although absorption is not too bad (about the same as for visible light) down as far as 2 cm (15 GHz).

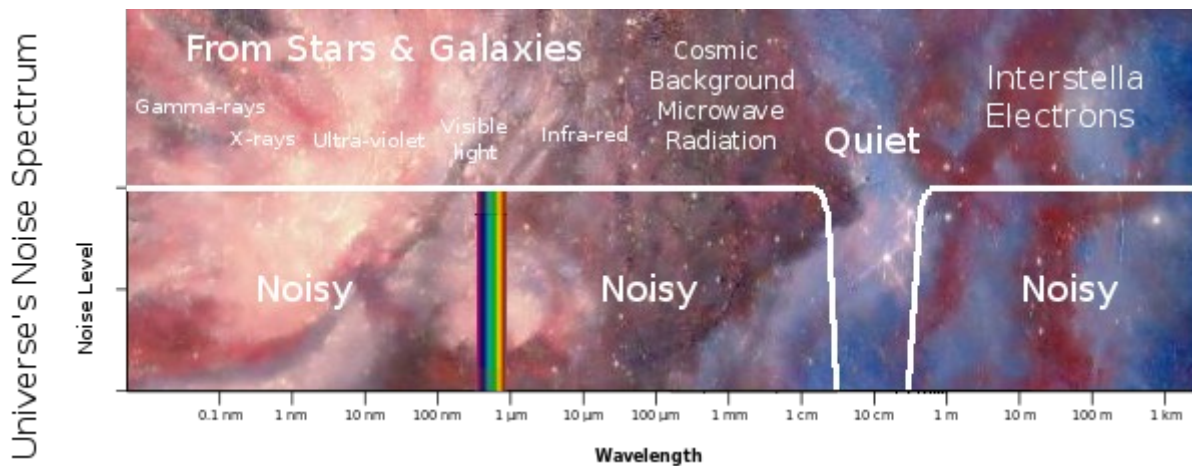
Waves longer than 12 metres are reflected by the various ionized layers within the upper atmosphere. This [ionospheric reflection](#) is a great advantage for HF radio communication. However, it is disastrous to communication with deep space. Outbound signals are reflected back and forth between the ionosphere and the ground. Inbound signals are reflected back out into space.

Note that HF was used to communicate with early artificial satellites. This was possible because these satellites orbited *below* the ionized F-layer.

This leaves only the open window from 10 GHz down to 25 MHz where radio transmissions can be beamed into space and received from space relatively unhindered. Not all of this window, however, is open for effective use for space communication.

The Noisy Universe

This is because of the second obstacle: electromagnetic noise from the universe itself. The universe is a noisy place, electromagnetically speaking. The spectrum of its electromagnetic noise is illustrated below. Note, however, that the flat white line merely indicates the ranges over which there is too much noise to allow communication. The noise level in reality varies widely across the whole spectrum.



Stars, galaxies and other more exotic cosmic objects pump out vast power levels of electromagnetic radiation over a large stretch of the spectrum from infra-red, through visible light and onwards through the ultra-violet, X-ray and gamma-ray ranges. From the infra-red range down to a wavelength of around 3 cm the universe itself rings with what is called the Cosmic Microwave Background. This radiation peaks at around 1.9 mm (160 GHz) or 1.06 mm (283 GHz), depending on how it is measured. It is currently thought to be the echo of the Big Bang that gave birth to the universe.

Then there's a gap. It extends from 3 cm to 30 cm. Within this range the universe is relatively quiet. In other words, its natural mechanisms and phenomena don't seem to emit much electromagnetic radiation within this range.

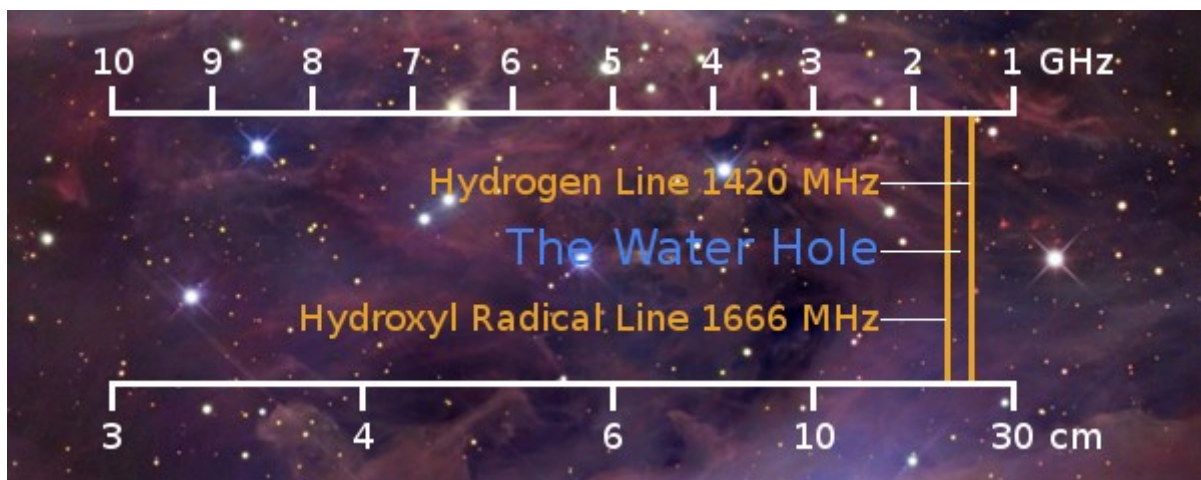
Beyond 30 cm, however, the universe becomes noisy again. Electromagnetic noise in this longer wavelength (lower frequency) range is thought to be generated mainly by free electrons as they circle in their coiled (helical) trajectories under the influence of the itinerant magnetic fields of interstellar space.

Notice that the range from 30 cm (1 GHz) to 12 metres (25 MHz) is part of the atmospheric window. Consequently, the atmosphere allows through this cosmic electron din over this lower portion of its open window. As you tune a radio receiver upwards in frequency from 25 MHz (12 metres) the background noise from outer space becomes increasingly apparent. When you get to the domestic VHF FM band from 88 to 108 MHz, the off-station noise level is terrible. If you have a scanner like my AR8600, you can listen in all the way up to 2 GHz. If you continue tuning (or scanning) upwards in frequency from the domestic FM band, the universe noise continues almost as far as 1 GHz. It then falls rapidly so that beyond 1 GHz the band becomes quiet.

It seems an intriguing coincidence that the left-hand edge of the atmospheric window at 3 cm (10 GHz) coincides quite neatly with the left-hand edge of the Cosmic Microwave Background profile. Consequently, we don't lose any spectrum space at that side.

Window into Space

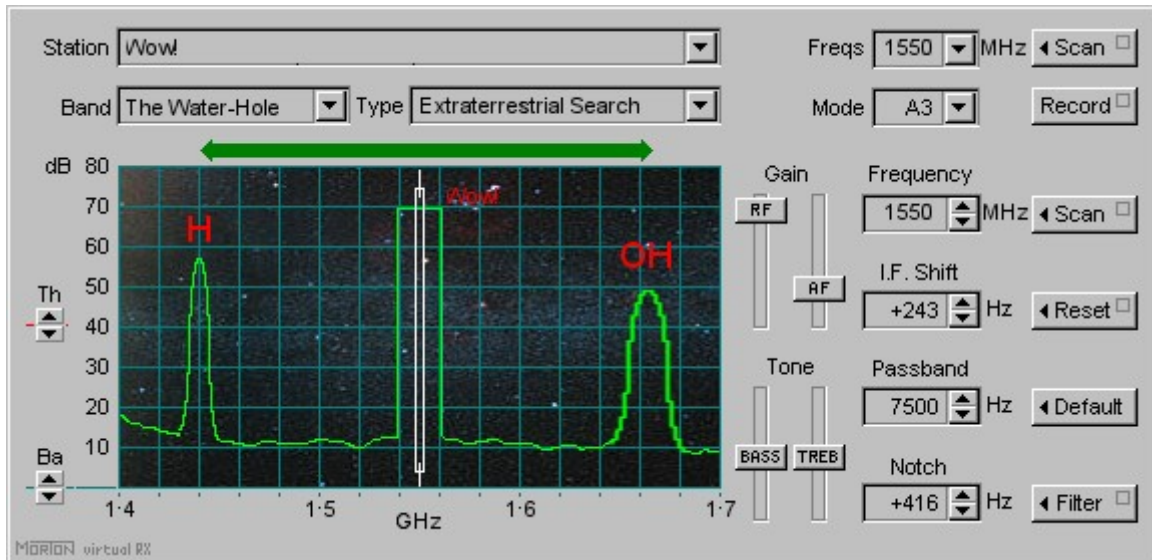
We are thus bequeathed with a radio window into outer space, that can be used for the transmission and reception of intelligence-bearing signals, that extends from 10 GHz (3 cm) down to 1 GHz (30 cm). This Quiet Band is illustrated below. In this diagram I have kept the same sense as the initial NASA diagram at the beginning of this article. That is, I show wavelength increasing from left to right. However, I have changed from a logarithmic scale of wavelength to a linear scale of frequency, which better illustrates the band's intelligence-carrying capacity.



Although the universe is ostensibly quiet within this range, it does emit electromagnetic radiation on what I like to think of as two very poignant spot frequencies. These are known as the Hydrogen Line at 1420 MHz (actually 1,420,405,751.77 Hz) and the Hydroxyl Radical Line at 1666 MHz. This radiation is produced respectively by the vast quantities of hydrogen H atoms and hydroxyl OH radicals that exist in interstellar space. The positions of these two natural beacons within the Quiet Band are shown in the above diagram.

Water is essential to life. At least it is to the kind of life we know about here on Earth. Under Earth-like conditions, the hydrogen atom and the OH radical combine to form water. This is why the 246 MHz of band-space between these two natural emission lines is referred to as the Water Hole.

Devotees to the search for extraterrestrial intelligence think that alien beings far away would also recognise the significance of H and OH forming water, which is essential for life. From this they assume that if such beings wished to contact us, they would naturally call us from within the Water Hole. So they tune their receivers as depicted below. Note that the frequency scale is now shown in the more conventional sense of increasing from left to right.



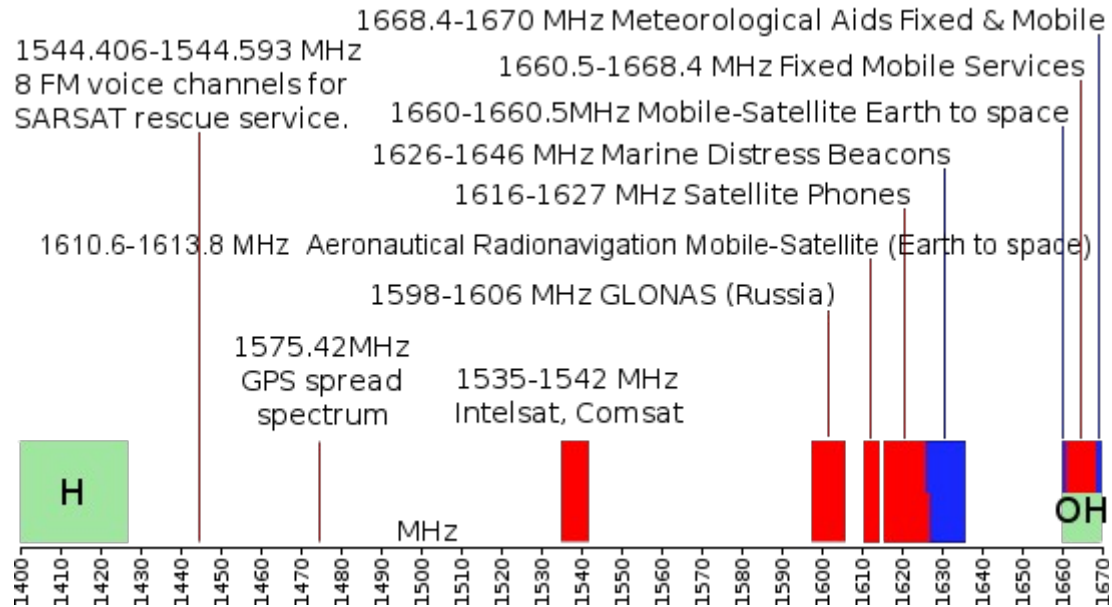
This is all very interesting and certainly fires the imagination. However, it is a bit restrictive. It could only apply to intelligent beings whose life-form is based on hydrocarbons and water on an Earth-like planet. Planets with a different atmosphere probably have their windows into space in other parts of the spectrum where our atmosphere blocks all signals. In this case, their radio windows would be in ranges where the universe is too noisy.

ET could, of course, opt to transmit his signal from a space station. Without any planetary atmosphere to absorb or reflect the signal, it could be transmitted in any part of the electromagnetic spectrum. Notwithstanding, it would still need to be within the Quiet Band, otherwise it would be drowned out by the radio noise created by the universe itself.

Pollution in The Water Hole

Unfortunately for these alien hunters, our Water Hole is polluted, and becoming more so with the passing years. As shown below, there are already many artificial radio sources within this band.

The Quiet Band as a whole is 9 GHz wide. That is 9000 times the size of the Medium Wave Broadcast band and 450 times the size of the domestic VHF FM band. There is no shortage of band-space for both terrestrial and Earth-space services.



[I'm neutrally sceptical.](#) Nevertheless, I think it would be a shame if ET were trying to call us from within a chunk of the Water Hole occupied with the Earth-bound transmissions of satellite phone and navigation services. I think it would therefore be a nice gesture for the International Telecommunications Union to allocate the Water Hole exclusively to the search for extraterrestrial intelligence and leave the SETI freaks in peace to look for their little green men.



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