Comment on: Auroral spectra as a tool for detecting extraterrestrial life by S. Akasofu

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In a recent article S. Akasofu [1999] suggested to use auroral spectra as a tool for detecting extraterrestrial life. The author argues that the green line of atomic oxygen at 557.7 nm wavelength is a direct evidence for the existence of free oxygen in a planetary atmosphere. As the green line in the terrestrial aurora "arises mostly from the fact that plants release abundant free oxygen into the atmosphere by the photosynthesis process", the detection in an extraterrestrial aurora would indicate that "the possibility of the presence of plant life is high." This is a great idea because auroral spectra point to two key elements of the existence of life, atmospheric oxygen and a magnetic field. It also extends the search for extraterrestrial intelligence to the search for lower life forms.

However, there are a few considerations in the article which we would like to comment on. We see especially some technical and geophysical problems in detecting this particular auroral line. Furthermore, we think other atmospheric emissions are better suited for the detection of free molecular atmospheric oxygen.

If we assume a solar system with a Sun-like star and an Earth-like planet, then we may expect to see an auroral zone of approximately $8 \cdot 10^6$ km^2 area if our look direction is aligned along the dipole axis of the planetary magnetic field. A bright aurora might show 10 kR from the whole auroral zone. S. Akasofu mentions that "the planets expose their full dark sides to Earth once during their revolution around their parent star." However, at this position the planet is right in front of or very close to the star and the stellar continuum would be so bright that the detection of the auroral line might be very difficult.

The same planet exposes approximately $2.5 \cdot 10^8$ km^2 of its surface to the star light. On Earth the sunlight produces a 557.7 nm dayglow of the order of 1 kR [*Noxon,* 1967]. Therefore, even if the extraterrestrial planet is in a position where the observer from Earth sees only half of its star-illuminated surface, the dayglow emission would be about twice as bright as the aurora ever gets in the most favorable observation geometry. This observation geometry would also give a few arc-milliseconds of separation between the star and the planet which would make the light detection much easier.

We agree with the author about the importance of auroral spectra as an indirect evidence of the existence of a planetary magnetic field. The Mariner satellite spectra of Mars' dayglow contain several UV features from atomic oxygen and a 12.7 kR emission at 557.7 nm has been calculated [*Fox and Dalgarno,* 1979]. Therefore, the detection of just this green line emission is not an evidence for the existence of life because we know that there is no life on Mars.

The author already mentions "a number of prominent atomic oxygen emissions in the FUV range". The most prominent emission is the oxygen OI triplet at 130.4 nm wavelength which produces a dayglow of approximately 10 kR on Earth [Meier, 1991]. Since it is 10 times brighter this emission could be much easier detected than the 557.7 nm line. However, stars contain oxygen. For instance our sun emits a considerable amount of the 130.4 nm atomic oxygen triplet and the separation of stellar and planetary emission might be impossible.

Another important emission in the dayglow of the Earth is the hydroxyl (OH) emission in the middle infrared which is a very important result of the photochemistry of ozone creation from atomic oxygen and its destruction by hydrogen producing the OH infrared emission. This emission peaks between 1400 and 1700 nm and produces several 10 kR in the airglow. If we consider ozone an additional prerequisite to the existence of life, this emission could give additional information about the conditions on extraterrestrial planets.

One of the brightest atmospheric emissions is the 761.9 nm emission of the O_2 (0,0) atmospheric band. It produces several hundred kilo-Rayleigh in the dayglow and may produce several mega-Rayleigh in an electron aurora. On Earth this emission can not be observed from the ground because of the strong absorption by the lower atmospheric O_2 and has to be observed from a satellite or rocket. The detection of this emission in a nightside extraterrestrial aurora should be easier than the detection of the green line due to the brightness. The detection of this emission in the extraterrestrial dayglow should also be easier because the background from the planetary surface reflection of starlight should be reduced by lower altitude oxygen absorption. The greatest advantage of this emission is the fact that stars do not contain molecular oxygen and any detected emission has to come from a planetary atmosphere. Therefore, the emission of the atmospheric band would be the brightest indication of molecular oxygen in an atmosphere and certainly a better candidate for the detection of life on any extraterrestrial planet.

References

Akasofu, S., Auroral spectra as a tool for detecting extraterrestrial life, *Eos, 80,* 397, 1999.

Fox, J. L. and A. Dalgarno, Ionization, luminosity, and heating of the upper atmosphere of mars, *J. Geophys. Res., 84,* 7315, 1979.

Meier, R. R., Ultraviolet spectroscopy and remote sensing of the upper atmosphere, *Space Sci. Rev., 58,* 1, 1991.

Noxon, J. F., Dayglow observations, in *Aurora and airglow,* Reinhold Pub., New York, 1967.

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