Solar global properties at the highest resolution

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The true dawn of multimessenger astronomy

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Introduction [edit]

The discovery of astrophysical sources of gravitational waves has been accompanied by detections of the sources in ordinary electromagnetic radiation - a physically distinct "messenger". This has been touted by astronomers as the dawn of "multi-messenger astronomy" , with the messengers being gravitational waves, electromagnetic waves, neutrinos, and potentially, the cosmic rays themselves. This Nugget points out that a diverse suite of astronomical messengers has existed for solar flares since Carrington's discovery of SOL1859-09-01. This list has grown from three (at that time) to many, and of course research work on the physics of solar flares and CMEs depends heavily on exploiting this list.

The solar multi-messenger list [edit]

1) **Electromagnetic radiation**. Of course Carrington saw the flare in white light, ordinary electromagnetic radiation. Nowadays we have become

Three topics

1) The distribution of electrical potential on the photosphere

2) Solar global properties inferred at granulation cell center

3) True height structure of the solar limb

1. Electrical potential in the solar atmosphere

• The electrical potential is the energy required to bring a unit charge from infinity to the point of interest. It is analogous to the gravitational potential but is much more complicated, for which we blame Benjamin Franklin.

• One generally cannot detect it via remote sensing, although in a collisionless plasma the particle distribution functions do show it.

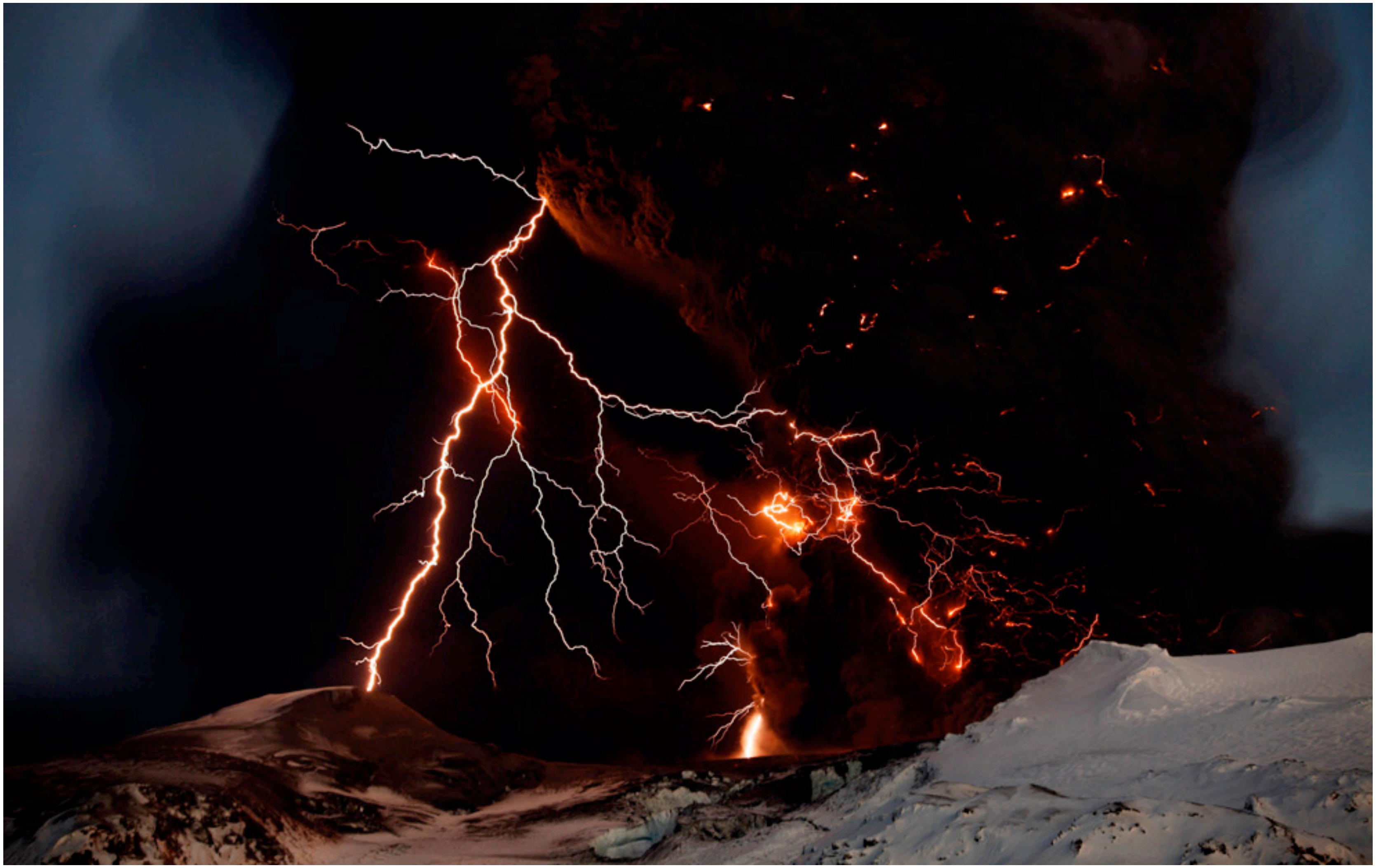
• We expect potentials of a few V; the Rosseland-Pannekoek potential is about 1 kV and the convective potential of the Earth's magnetosphere is of order 100 kV.

Electrical potential in the solar atmosphere – so what?

• The non-potential fields of the corona require body currents that are non-neutralized (the Melrose-Parker debate is now resolved) and store energy inductively.

• The electrical potential therefore varies in 3D and we need to know how to understand the (tensor) conductivity.

• DKIST can resolve flux tubes and maybe characterize the potential via the Stark effect (Foukal) and/or Ampere’s law. How do inferred currents relate to observed structures?



Multi-phase plasmas, double layers, discharges,
Rutten's "contrails", exobiology

2. Solar global properties inferred at granulation cell center

• The measurement of the gravitational redshift in the photosphere is a classically important and difficult observation.

• DKIST gives us access to spectroscopy in pristine granule interiors, even at the opacity minimum.

• We can expect discovery of solar global properties even if we’re not interested in confirming Einstein.

Global temperature mapping

- The surface temperature of the photosphere will vary with position and reflect interior flows.
- The state of the art for pole/equator differential temperature variation is a few K.
- DKIST granule-center spectroscopy should greatly improve this.
- This capability may offer a new window into the solar interior structure, complementary to that of helioseismology.

3. True geometrical height scale

• Semi-empirical model atmospheres scale against optical depth, and in general models require calibration in 3D.

• “Rugosity” appears in the photosphere at radio and UV wavelengths, and we can expect effects throughout the atmosphere, e.g. via foreshortening in magnetized regions (Wilson depression; Simon & Zirin 1969; faculae; seismic radius, *etc.*).

• DKIST can resolve all this stuff.

Conclusions

- Even with a tiny field of view, DKIST can contribute to many areas of global interest because it can resolve the constituent structures of the atmosphere.
- For example, we may get a glimpse of the “true” plasma physics required by the variations of electrical potential.
- We may introduce global constraints on solar interior structure via precise temperature determinations.