# Possible density diagnostic by collisional depolarization in planetary atmospheres

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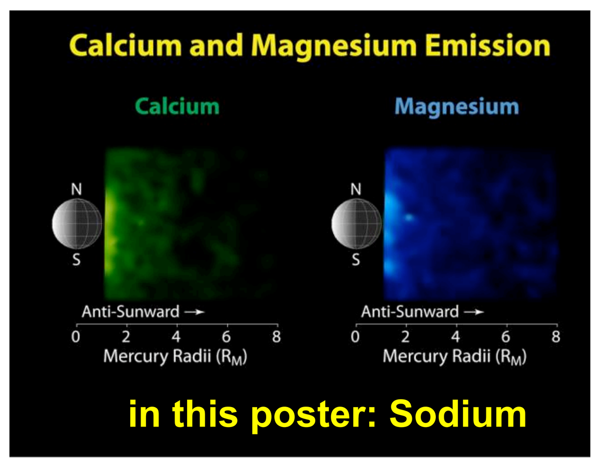
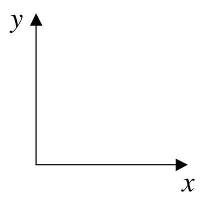
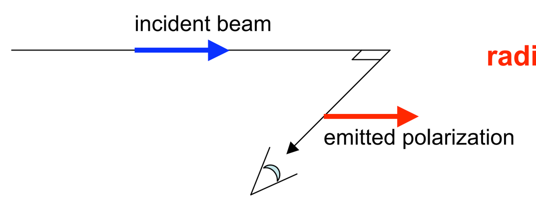


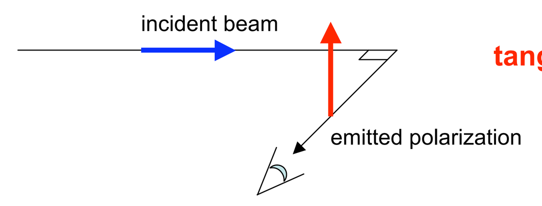

Polarization axis $P=\frac{Q}{I}=\frac{I_x-I_y}{I_x+I_y}$




$P=\frac{Q}{I}>0$




$P=\frac{Q}{I}<0$

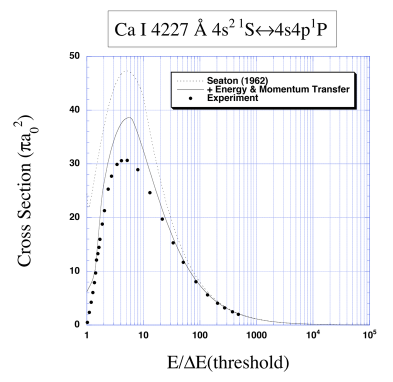



## Our theory:

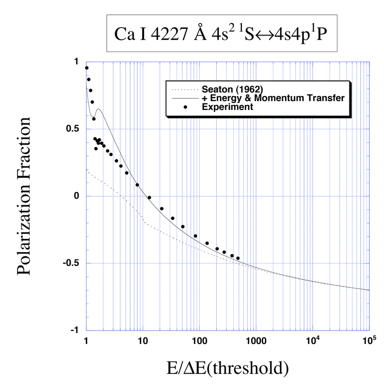
### O I 6300 Å red line of Earth Aurorӕ: impact polarization in a forbidden line

**Dipolar electric (permitted) transition (Bommier, SPW4):**

cross-section




impact polarization



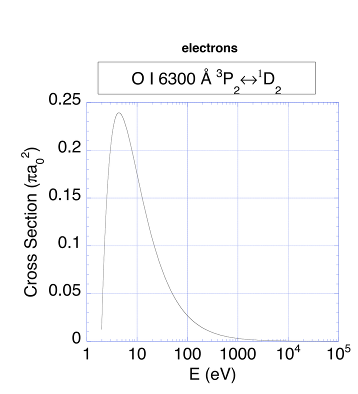

vanishes at 12 times the threshold energy

**Quadrupolar electric (forbidden) transition (this line):**

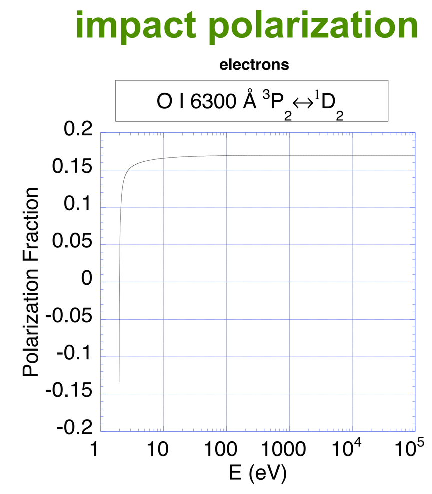
Bommier, Sahal-Bréchot, Dubau, Cornille, 2011, Ann. Geophys. 29, 71

semi-classical theory scaled on 1 energy point of the quantum calculation of Barklem (2007, A&A 462, 781)

cross-section



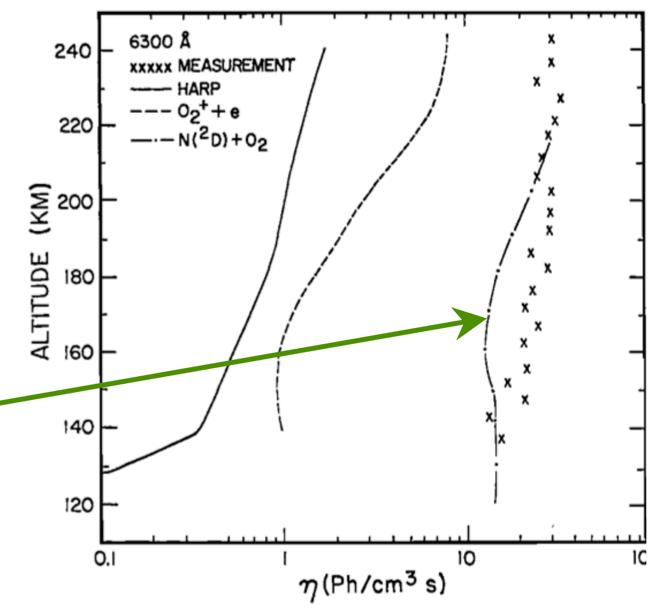

impact polarization




vanishes much closer to the threshold energy

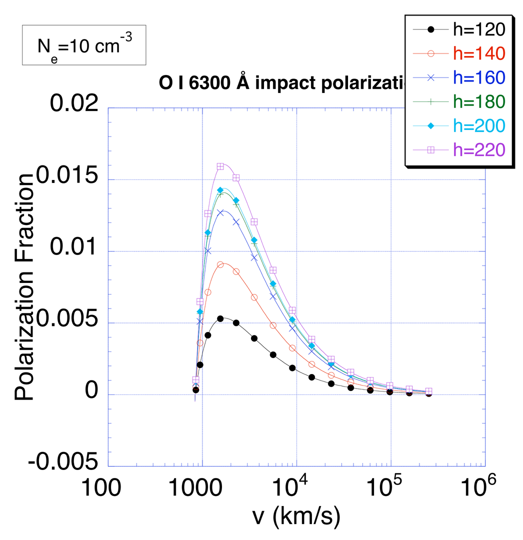
but the observed polarization (Lilensten et al., 2008, GRL 35, 8804, reanalyzed by Bommier et al., 2011) is yet lower (a few % ?)
⇒ existence of a collisional depolarization ?

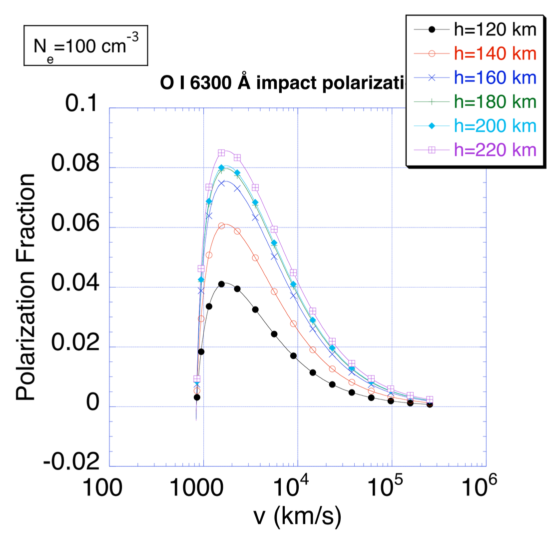
Rusch, Gérard & Sharp (1978, GRL 5, 1043) suggest that the main populating mechanism of the upper line level $O(^1D)$ is the reaction $N(^2D) + O_2 \rightarrow NO + O(^1D)$

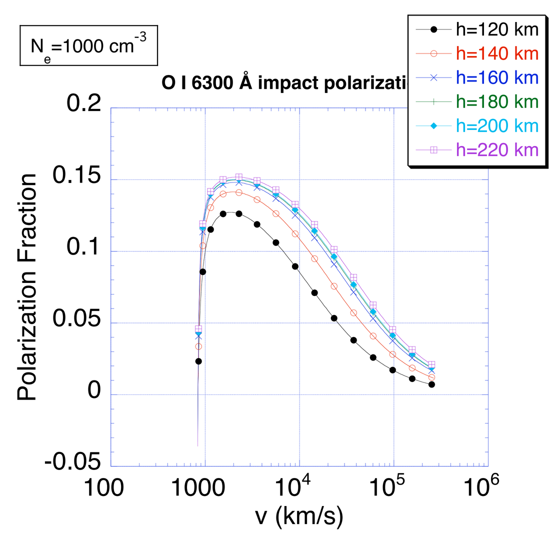


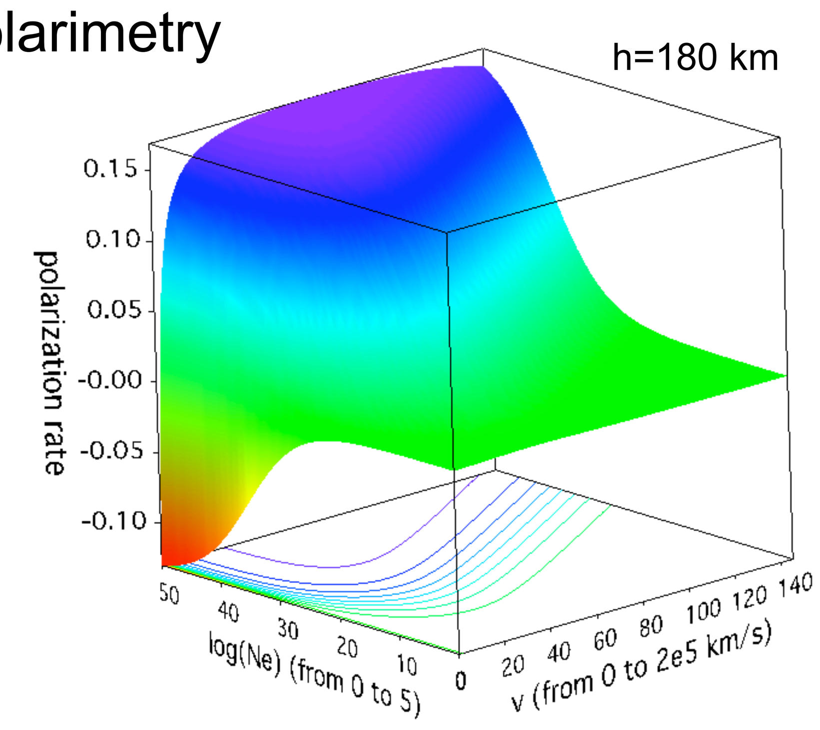

the volume emission rate modeled from this reaction, compared to observations (Fig.1 of their paper)

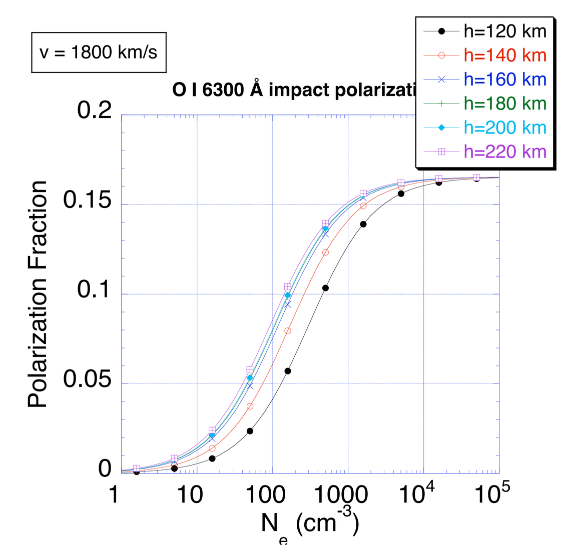
We have computed the equilibrium between this isotropic depolarizing process and the impact excitation. Taking all the constituent densities from Rusch et al. (1978), we show how the polarization depends on the impact electron density and velocity, that could then be determined by polarimetry




(velocity corresponding to the threshold energy: 832 km/s)

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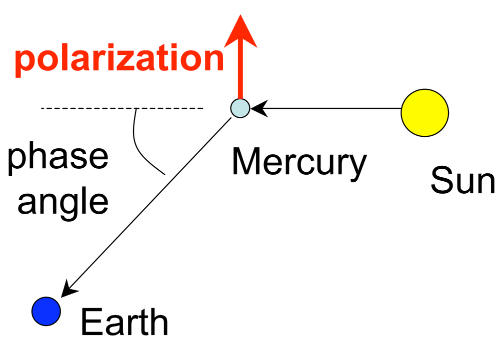



## Scattering Polarization of the Na I D2 5890 Å line emitted by Mercury's exosphere

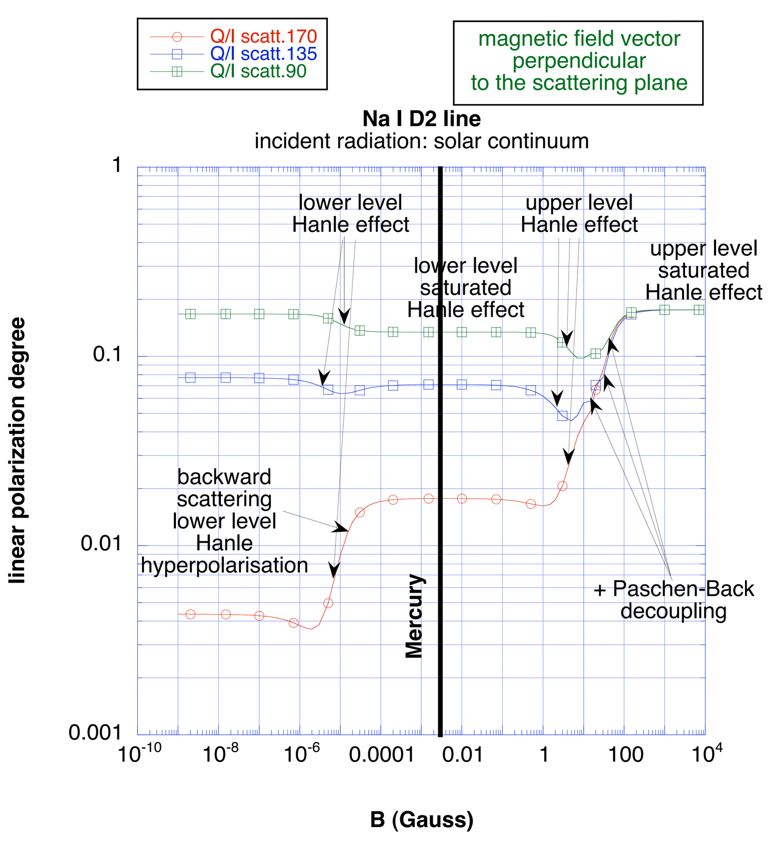
(THEMIS telescope observations, Tenerife, © CNRS, A. López Ariste, poster, this conference, this session)

theory of the Hanle effect in Zeeman and Paschen-Back couplings for the multiterm atom (Bommier, 1980, A&A 87, 109) applied to the Na I D lines, + depolarisation by Na+H collisions (Kerkeni & Bommier, 2002, A&A 394, 707)

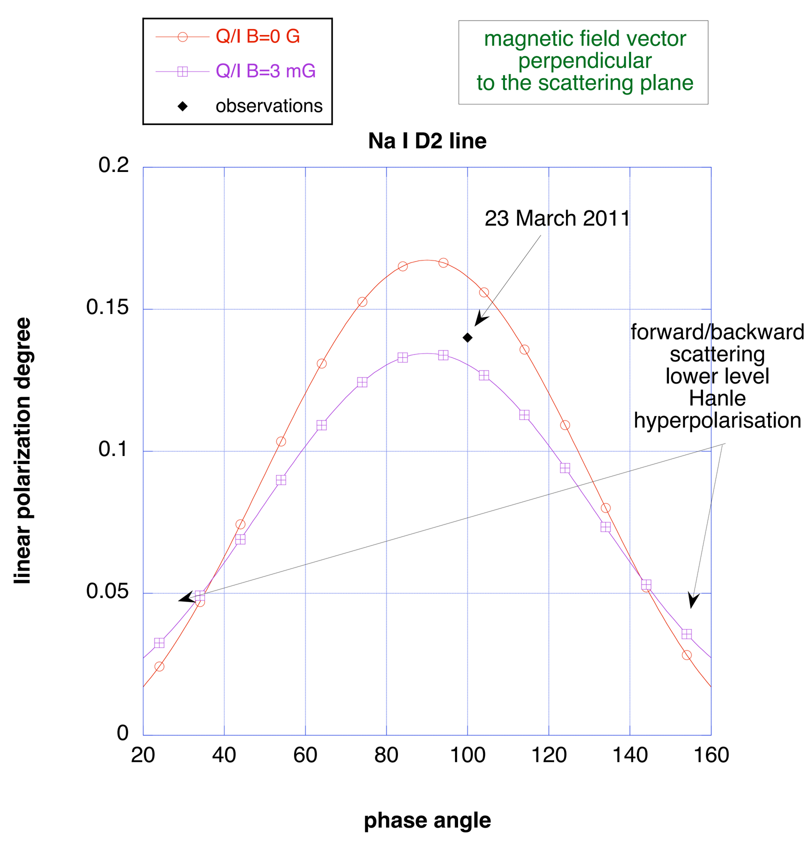
in Mercury's exosphere: major collisions Na+Na, Na density $10^6$ cm$^{-3}$, too weak for any effect:
w (Van der Waals) = 2.14e-8 s$^{-1}$ per collider. If they are $10^6$ cm$^{-3}$: w=2.14e-2 s$^{-1}$
lower level inverse lifetime 89.8 s$^{-1}$ (radiative absorption), upper level inverse lifetime 6.16e7 s$^{-1}$: lifetimes much shorter than w$^{-1}$

**⇒ no depolarization by collisions**

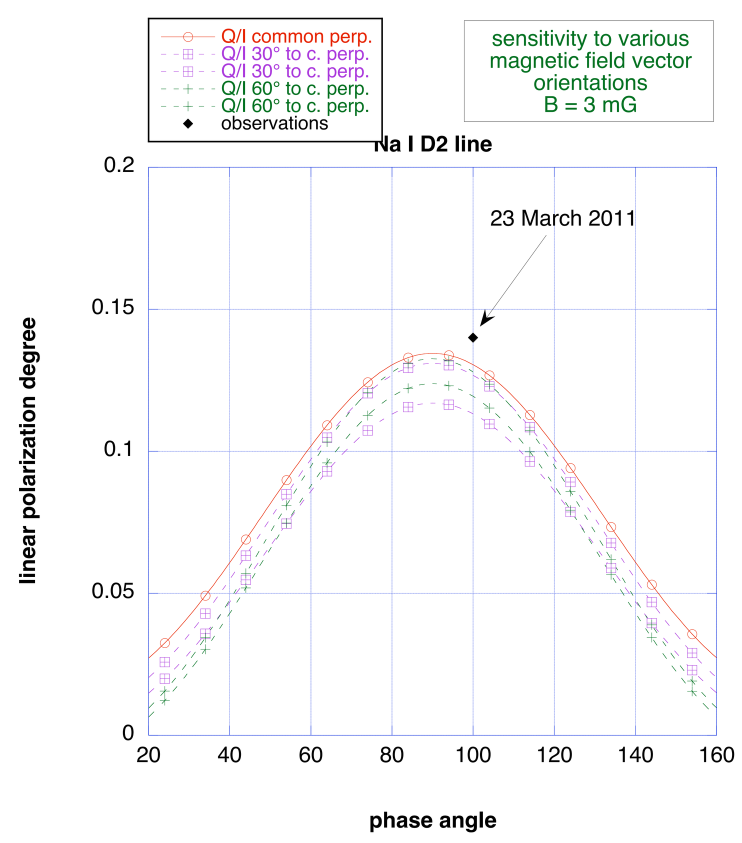
**Mercury's magnetic field: dipole, 3mG in exosphere**
**to be observed: Na I D2 lower level saturated Hanle effect**




The different regimes of the Na I D2 line Hanle effect, as a function of the magnetic field strength.




The observation may confirm the existence of the 3 mG Mercury's magnetic field (purple curve), with respect to the zero field case (red curve), but the field strength cannot be precisely determined (saturated lower level Hanle effect)




In the lower level saturated Hanle effect, the sensitivity to the field direction remains weak.