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Magnetic fields in comet 67P/Churyumov-Gerasimenko

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Abstract. On 2014 August 06 the Rosetta spacecraft arrived at comet 67P/Churyumov-Gerasimenko. Since then, the spacecraft accompanied the comet on its journey around the Sun (Glassmeier et al. 2007a), until the end of the mission on 2016 September 30. This work tries to understand the possible connections between the 665 reported diamagnetic regions (Goetz et al. 2016), detected from April 2015 to February 2016 around the comet 67P/Churyumov-Gerasimenko, with the fluxgate magnetometer of the Rosetta Plasma Consortium (RPC-MAG), when the heliocentric distance of the comet from the sun varied from 1.8 to 2.4 AU and the 34 reported outbursts (Vincent et al. 2016), detected from July to September 2015, with the Optical, Spectroscopic, and Infrared Remote Imaging System (OSIRIS) cameras, when the ESA's Rosetta spacecraft changed the cometocentric distance from 155 to 817 km.

Resumo. Em 6 de agosto de 2014, a sonda Rosetta chegou ao cometa 67P / Churyumov-Gerasimenko. Desde então, a sonda acompanhou o cometa em sua jornada ao redor do Sol (Glassmeier et al. 2007a), até o final da missão em 30 de setembro de 2016. Este trabalho tenta entender as possíveis conexões entre as 665 regiões diamagnéticas relatadas (Goetz et al. 2016), detectadas de abril de 2015 a fevereiro de 2016 em torno do cometa 67P / Churyumov-Gerasimenko, com o magnetômetro fluxgate do Rosetta Plasma Consortium (RPC-MAG), quando a distância heliocêntrica do cometa ao Sol variou de 1,8 a 2.4 UA e as 34 explosões relatadas (Vincent et al. 2016), detectadas de julho a setembro de 2015, com as câmeras Óptica, Espectroscópica e Sistema de Imagem Remota Infravermelha (OSIRIS), quando a sonda Rosetta da ESA mudou a distância cometocêntrica de 155 para 817 km.

Keywords. Comets: individual: 67P / Churyumov-Gerasimenko

1. Data

The 34 outbursts images (Vincent et al., 2016) detected by OSIRIS are compared with the identified 665 intervals of the diamagnetic cavity reported by Goetz et al., (2016). These 665 intervals from 20 April 2015 to 17 February 2016 could be identified when Rosetta was located in a zero-magnetic-field region. The magnetic field data were recorded by the Rosetta Plasma Consortium MAGnetometer (RPC-MAG), a fluxgate magnetometer with a resolution of 31 pT and a range of ± 16.384 nT (Glassmeier et al., 2007b).

On the days of outburst occurrences (July to September 2015), Goetz et al., (2016) recorded 114 diamagnetic cavity intervals, Table 1. All the data are in the Coordinated Universal Time (UTC).

2. Motivation - Model

The Rosetta spacecraft is assumed to be stationary relative to the comet because its orbital velocity is slow, about 1 ms^{-1}, so RPC field sensors can only register a diamagnetic cavity if it travels through the spacecraft (Fig. 1), this means that we only expect changes in the fields if the outburst displaces and pushes the cavity significantly away.

Fig. 1 shows the temporal evolution of the outburst influence in the diamagnetic cavity: the time t_0 represents the initial situation with Rosetta measuring the magnetic field in the vicinity of the comet, the diamagnetic cavity is closer to the comet, therefore, it could not be detected.

Suddenly, an outburst occurs at time t_1, and with the release of gas and dust, it pushes the cavity away from the comet. The disturbed cavity reaches the spacecraft at time t_2, and now the RPC field sensors can register the existence of a diamagnetic cavity.

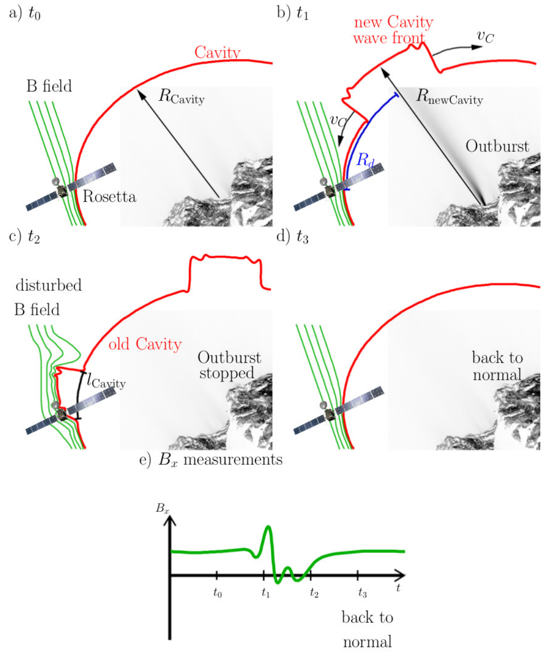

Figure 1. Displacement and movement of the diamagnetic cavity as a function of the outburst.

Finally, at time t_3, the cavity returns to its initial position because no activity on the cometary surface occurs.

Fig. 1 shows an arbitrary plane. The vector components of y- and z- also exhibit similar behaviour.

Table 1. Occurrence of an outburst compared to diamagnetic cavity (DC) intervals from July to September 2015

Outburst number	Outburst day	Outburst time	DC occurrence	Outburst number	Outburst day	Outburst time	DC occurrence
1	Jul 10	02:10:18	3	18	Aug 23	01:39:38	–
2	Jul 10	03:38:09	–	19	Aug 23	15:12:48	–
3	Jul 26	20:22:42	52	20	Aug 26	07:51:04	–
4	Jul 27	00:14:29	2	21	Aug 27	22:58:04	–
5	Jul 28	05:23:42	–	22	Aug 28	02:29:21	–
6	Jul 29	13:25:28	10	23	Aug 28	10:10:57	–
7	Aug 01	10:53:15	–	24	Sep 05	08:50:02	–
8	Aug 01	15:44:50	–	25	Sep 05	09:00:02	–
9	Aug 03	17:27:03	33	26	Sep 10	08:59:49	2
10	Aug 05	07:25:05	–	27	Sep 10	13:06:14	2
11	Aug 05	08:05:15	–	28	Sep 10	13:36:14	2
12	Aug 08	15:21:48	–	29	Sep 10	14:11:15	2
13	Aug 09	09:15:14	1	30	Sep 10	18:57:41	2
14	Aug 12	17:21:20	–	31	Sep 10	19:27:41	2
15	Aug 21	09:44:53	7	32	Sep 12	09:41:00	–
16	Aug 22	06:47:04	4	33	Sep 14	18:47:00	–
17	Aug 22	23:46:21	4	34	Sep 26	12:03:32	–

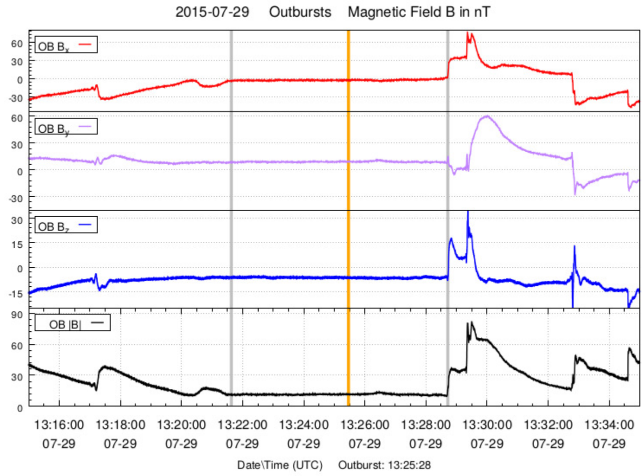

FIGURE 2. Variation in magnetic field on 2015 July 29 showing the diamagnetic cavity interval from 13:21:38 UTC to 13:28:43 UTC and the outburst at 13:25:28 UTC. The three vector components and the magnetic field magnitude registered from the outbound sensor (OB) and from the inbound sensor (IB) are shown. The spacecraft's distance to the comet was 186.8 km.

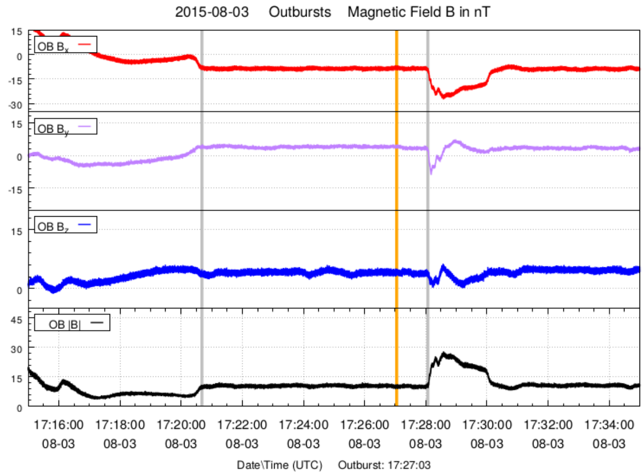

FIGURE 3. Variation in magnetic field on 2015 August 03 showing the diamagnetic cavity interval from 17:20:41 UTC to 17:28:04 UTC and the outburst at 17:27:03 UTC. The three vector components and the magnetic field magnitude registered from the outbound sensor (OB) and from the inbound sensor (IB) are shown. The spacecraft's distance to the comet was 218.5 km.

3. Conclusions

A series of 34 transient releases of gas and dust by the nucleus of comet 67P/CG over three months surrounding its perihelion passage in 2015 mid-August was compared with a series of 665 diamagnetic cavity intervals at the same period. The RPC-MAG data were analysed and compared with the OSIRIS data to find possible correlations between the occurrences of outbursts and the diamagnetic cavity intervals. The distance from the cavity boundary to the nucleus depends on long-term trends in the rate of outgassing, but there is no direct relation to short time variations such as outbursts. In only three of 34 outbursts, a possible influence on the diamagnetic cavity is detected. In the other 31 outbursts, either the Rosetta spacecraft was in an unfavorable position in regard to the outburst-cavity interaction region, the outburst intensity was too weak to push the cavity boundary towards the spacecraft or too distant to the cavity. Probably the formation of instabilities at the cavity boundary and a higher than expected outgassing rate could be the possible explanation for the behaviour of the diamagnetic cavity at 67P/CG.

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