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Observations during a triple magnetic conjunction CLUSTER-FAST-Sondeström are examined. CLUSTER was on an outbound pass through the exterior cusp. The IMF pointed south-west throughout. A solar wind dynamic pressure release, whose arrival at CLUSTER can be very well timed, shifted CLUSTER into the cusp boundary layer at the poleward edge of the cusp (geomagnetic $B_z < 0$, $B_x > 0$). There it observed 5 flow bursts and magnetic perturbations which are Alfvénic in nature. We interpret these flow events as being due to a sequence of reconnected flux tubes passing over CLUSTER (i.e., flux transfer events, FTEs). This interpretation is further supported by (i) the observation at FAST of a staircase cusp signature on magnetic field lines nominally connected to CLUSTER; (ii) the observation by the Sondestrom and CUTLASS radars of a sequence of pulsed poleward enhancements of ionospheric flows (PIFs) which are (a) in one-to-one correspondence with the flow bursts at CLUSTER and which (b) are well known from previous work to be an ionospheric signature of FTEs; and (iii) Observations of the ion flow bursts at Polar, situated in the magnetosphere further downstream of CLUSTER, whose directional characteristics are consistent with the interpretation proposed above. The work extends previous studies of signatures of FTEs by showing flow bursts associated with reconnection at sub-cusp latitudes but which are seen behind the cusp.

Acknowledgements: This work is supported by NASA Grants NAG 5-10883, NAG5 - 11803, NAG 5-11676, and NAS5-31283.

SM12B-08 1545h INVITED

Cluster Observations of Reconnection at the Magnetopause and in the Cusp: Implications for the Large-Scale Nature of Reconnection

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We survey the occurrence of reconnection at the magnetopause and in the cusp using measurements from the CIS and FGM experiments. We present evidence for reconnection occurring both equatorward and poleward of the cusp for different IMF orientations. The multi-spacecraft measurements reveal that under steady IMF conditions, reconnection is large scale and occurs continuously over an extended period of time, but the reconnection rate may be modulated.

SM12B-09 1605h INVITED

The Discontinuous IMF-Dependent Entry of Solar Wind Ions into the Magnetosphere

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We have investigated the entry of solar wind ions into the magnetosphere by tracing particle orbits in time-dependent electric and magnetic fields obtained from a three-dimensional global magnetohydrodynamic (MHD) simulation of the magnetosphere. The MHD simulation begins with a 2-hour period of northward interplanetary magnetic field (IMF). The IMF then rotates by 45° every two hours. The final four hours of the simulation has southward IMF. Ions were launched in the solar wind at time intervals corresponding to the midpoint of each IMF interval and collected after crossing the magnetopause current layer. We found that the region of the upstream solar wind that mapped to the magnetopause entry regions was parallel to the $y-z$ orientation of the IMF. Moreover, ions generally entered into the magnetosphere through the cusps and through the reconnection regions for that IMF orientation. In the cases with a finite IMF B_y , the cusp entry region was stretched toward lower latitudes and had a larger longitudinal extent than the northward or southward IMF cases and showed similarities to the double cusp feature observed by the DMSP spacecraft. The characteristics of ion entry for each IMF orientation as well as the acceleration of ions in the cusp and reconnection entry regions will be compared and analyzed.

SM12B-10 1625h

Double Cusp: Model Prediction and Observational Verification

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Our open-field line particle precipitation model has successfully simulated the large-scale particle precipitation features in the observed cusp, mantle, polar rain, and open-field line LBL regions. When IMF is strongly duskward/dawnward and weakly southward, the open-field line particle precipitation model predicts the occurrence of a double cusp near noon: one cusp at lower latitude and one at higher latitude. The lower latitude cusp ions originate from low-latitude magnetosheath whereas the higher latitude ions originate from the high-latitude magnetosheath. The lower latitude cusp is located in the region of weak azimuthal $E \times B$ drift, resulting in a dispersionless cusp, as would be observed from a typical meridional trajectory of a polar orbiting satellite. The higher latitude cusp is located in the region of strong azimuthal and poleward $E \times B$ drift. Because of a significant poleward drift, the higher latitude cusp dispersion has some resemblance to that of the typical southward IMF cusp. Occasionally, the two cusps have such narrow latitudinal separation that they give the appearance of just one cusp with extended latitudinal width. From the 40 DMSP passes selected during periods of large (positive or negative) IMF B_y and small negative IMF B_z , 30 of the passes exhibit double cusps or cusps with extended latitudinal width. The double cusp result is consistent with the following new statistical results: (1) the cusp latitudinal width increases with $|IMF B_y|$ and (2) the cusp equatorward boundary moves to lower latitude with increasing $|IMF B_y|$. Other satellites, e.g. POLAR, have also observed this double cusp signature.

SM12B-11 1640h

Cusp Electron and Ion Structures Observed by FAST

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The high-time resolution observations by FAST resolve burst-like electrons and nonmonotonic ion dispersion in the cusp region. The burst-like precipitating electrons are correlated with electric field variations in the frequency range of 0.2-1Hz, which are most easily explained as propagating Alfvén waves. Alfvén waves cause strong ion heating and outflow in the polar cap boundary acceleration region (dayside polar cusp and near-midnight polar cap boundary). Ion structures are associated with the direction and/or magnitude of the drift velocity which is in the opposite direction of the magnetic field perturbation in the Northern Hemisphere. From this it can be concluded that magnetosheath ion structures are a result of the spacecraft crossing flow streamlines. Each flow channel has its own history of dayside reconnection, therefore, the magnetosheath ion structures contain information of both the spatial and temporal variations of dayside reconnection.

SM12B-12 1655h

Global Observations of Flux Transfer Events and Their Effects on the Magnetosphere-Ionosphere System.

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Multi-instrument observations of the magnetosphere reveal the nature of direct coupling in the solar wind-magnetosphere-ionosphere system, namely dayside reconnection. A case study during which there was a highly favourable conjunction of an extensive array of spaceborne and ground-based instruments offered an excellent opportunity to study magnetic reconnection in situ, as well as its effects on the magnetosphere and ionosphere. Flux transfer events were observed by Geotail during an extended traversal of the dawn magnetopause. Extensive coverage of the entire dayside high-latitude ionosphere was achieved by all of the northern hemisphere SuperDARN radars, and accurate solar wind time delays were possible due to the position of the IMP8 spacecraft immediately upstream of the Earth's bow shock. The SuperDARN radars in the dawn sector, in the vicinity of Geotail's magnetic footprint, measured temporally varying convection velocities. Low-altitude satellites monitored both the size of the auroral oval and particle precipitation in the cusp footprint. Energy-dispersed cusp ions were detected by the DMSP-F11 spacecraft at the same time that an FTE was measured by the magnetically conjugate Geotail. Analysis of the field and plasma data at Geotail reveals details of the structure and motion of the newly reconnected flux tubes as they convected past the spacecraft. The implied location of magnetopause reconnection will be discussed.

SM21A MCC: Hall D Tuesday 0830h

Planetary Magnetospheres II Posters (joint with P, SA, SH)

Presiding: B H Mauk, Applied Physics Laboratory; R L Mutel, University of Iowa

SM21A-0520 0830h POSTER

A Global Model of Jupiters Magnetospheric Field

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We present a progress report on our effort to build a new model of Jupiter's magnetospheric field. We are using a five-minute averaged database of magnetic field from Galileo and all the other previous missions to Jupiter. As a first step we have constructed a new model of the structure and thickness of Jupiter's equatorial current sheet. The model incorporates the delay and hinging of the current sheet at large distances. The thickness of the current sheet is modeled as a sinusoidal function of local time such that the current sheet is at its thinnest in the dawn sector and is the thickest in the dusk sector.

To model the magnetic field of Jupiter's current sheet we use analytical models of disk-shaped current sheets similar to those advanced by Tsyganenko and Peredo [1994] for the Earth's current sheet. These models use an axially symmetric representation of the magnetic vector potential of a ring current to provide simple expressions for the calculation of magnetic field. Next, we use a general deformation technique [Tsyganenko, 1998] to introduce delay and hinging effects on the magnetic field of the Jovian current sheet.

Finally, we discuss the use of Cartesian harmonics in specifying the field of the magnetopause and the magnetotail current system. We also discuss the importance of including the 3.2 degree tilt between the Jovigraphic equator and the Jovian orbital plane in describing the structure of the Jovian current sheet.

SM21A-0521 0830h POSTER

Space Weather in the Io Plasma Torus

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Because many torus phenomena are difficult to observe, many aspects of torus dynamics, mass supply, chemistry, and energization are poorly constrained, despite extensive theoretical modeling. One feature of torus data hitherto underexploited for constraining these issues is time variation. Ion and electron heating, ion chemical reactions, and different modes of transport all have characteristic time delays resulting from their individual finite rates of action. These delays are made observable by fluctuations of torus inputs, that produce a cascade of time variations, and so can be estimated using time series analysis. System periodicities (such as Io's orbital and Jupiter's rotational period) can also be exploited to determine connections with torus mass and energy sources.

Therefore, we have analyzed time variations in Extreme Ultraviolet Explorer (EUVE) observations of the torus made during 1996 and 1999. Preliminary results indicate that S⁺ varies most strongly at the frequency of Io crossing the torus midplane, suggesting significant ionization of near-Io neutrals by the torus. We also see rapid variation of S⁺ and slow variation of its ionization product S⁺⁺, implying slow ionization of S⁺ and slow transport loss. Moreover, an apparent time-correlation of O⁺ with S⁺ suggests a common source such as SO or SO₂.

Work is continuing on the full 1993 - 1999 EUVE data archive, expanding the timescales sampled to both longer (≤ 6 yr) and shorter (≥ 1.5 hr) periods. Issues that may potentially be constrained include electron energization, ion chemistry, mass loading, and transport. Other data archives with extensive sampling that could be exploited include those of IUE, Voyager UVS, Cassini UVIS, and ground-based observations.

SM21A-0522 0830h POSTER

Turbulent heating of Jupiter's middle magnetosphere

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In this paper we give a possible explanation for the high ion temperatures of ~10⁸ K measured in the middle magnetosphere of Jupiter [Frank et al. 2002, Frank & Patterson, 2002]. In the absence of a significant heat source much lower temperatures are expected due to adiabatic cooling of the expanding magnetosphere. We show that the weak magnetohydrodynamic turbulent fluctuations observed in the middle magnetosphere dissipate energy at a rate that can account for the high

ion temperatures. We present a one dimensional temperature equation as a function of radial distance and find a temperature profile in good agreement with observations by the Galileo spacecraft.

SM21A-0523 0830h POSTER

Auroral Electron Beams in the Jovian Magnetosphere

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Bi-directional, field-aligned streams of hot electrons are detected with the plasma instrumentation of the Galileo spacecraft in Jupiter's magnetosphere in three different regions; (1) inside the Io flux tube where the thermal ions are hung-up with respect to the moon due to the high conductivity there, (2) in the plasma torus during flux-tube interchange events associated with radial transport of Iogenic plasma, and (3) in the plasma sheet at radial distances from Jupiter beyond about 20 Jovian radii, which is also a region where plasma flow velocities largely depart from those for rigid corotation. The energies of the electrons extend to several tens of keV and intensities are sufficient for production of auroral emissions. Similarities in the characteristics of the electron beams and the associations with non-corotation of the thermal plasmas are common features that link these observations from otherwise disparate regions and suggest the possibility of a common physical cause for the beams. In this presentation we exhibit evidence of the beams and their environs and discuss possible sources, with emphasis on the beams near and beyond 20 R_J that are magnetically conjugate to Jupiter's main rings of auroral luminosity.

SM21A-0524 0830h POSTER

Source Regions of Energetic Neutral Atoms From Jupiter

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We have discovered that two discrete source regions dominate the emission fluxes of energetic neutral atoms (ENAs) from Jupiter's space environment in the 10's of keV energy range. The source regions are: 1) a ring or torus of emission just beyond the orbit of Europa, and 2) Jupiter's exosphere which glows in ENAs as a result of the near-precipitation of energetic ions onto Jupiter's atmosphere. To identify these sources we: i) deconvolved the instrument response from the ENA images obtained by the Cassini Ion and Neutral Camera during the Cassini flyby of Jupiter in January of 2001 (Krimigis et al., 2002), and ii) combined the images with in situ data obtained from the Galileo Energetic Particle Detector (EPD). The trans-Europa ENA emission source requires neutral densities greater than 10 / cc, and perhaps 10's per cc depending on the exact distribution of the ENA emissions. Thus, we hereby confirm the inference of Lagg et al. (2001), developed using Galileo EPD energetic-ion angle distributions, of the presence of a much denser population of neutral gas in the vicinity of Europa than has been predicted on the basis of the volcanic sources at Io. The Jupiter exospheric ENA source strength offers the most direct measure yet obtained of the flux of energetic ions precipitating over all onto Jupiter's atmosphere.

Krimigis et al., A nebula of gasses from Io surrounding Jupiter, Nature, 415, 994, 2002.

Lagg, A., N. Krupp, J. Woch, and D. J. Williams, Evidence for an extended neutral torus at Europa, Unpublished Manuscript, 2001.

SM21A-0525 0830h POSTER

Update on Local Time and Radial Dependence of HOM/DAM Radio Emission Observed by the Galileo Plasma Wave Instrument

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We have previously reported on the local time and radial dependence of HOM/DAM radio emission observed by the plasma wave instrument on board the Galileo spacecraft. The original study covered portions of the first 17 orbits of the spacecraft, but the early morning and afternoon sectors of local time were observed at much smaller radial distances than the other local time quadrants. In the present study we have compiled data from the extended mission to present a much more comprehensive picture of the radio emission power levels and occurrence probabilities. We will discuss these findings in light of our current knowledge of the Jovian magnetosphere.

SM21A-0526 0830h POSTER

Joint Observations of Low-Frequency Jovian Radio Emissions with the Cassini and Galileo Spacecraft

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The Cassini gravity-assisted flyby of Jupiter has provided nearly continuous Radio and Plasma Wave System (RPWS) data from the early part of 2000 to the present (the distance between the Cassini spacecraft and Jupiter has ranged from 137 to over 5000 Jovian radii). During this period, the Galileo Plasma Wave System (PWS) in orbit around Jupiter has also obtained many days of radio and plasma wave data. The availability of simultaneous measurements from two different spacecraft provides a new opportunity to examine the characteristics of the new Jovian radio emissions, including the low-frequency radio emissions in the 1 to 50 kHz range. These low frequency emissions have a variety of characteristics, and include narrowband tones, quasi-periodic bursts, and three types of continuum-like emissions (escaping, trapped, and anomalous continuum). Furthermore, the ability of the Cassini RPWS system to perform direction finding on many of these emissions provides insight on source locations and processes. We will examine the Cassini and Galileo observations of these emissions, compare them to the earlier results from Voyager and Ulysses, and discuss the source locations and generation mechanisms.

SM21A-0527 0830h POSTER

Multi-Fluid Simulations of the Jovian Magnetosphere

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The dynamics of the Jovian magnetosphere are controlled by three sources; the solar wind, the Jovian ionosphere, and the Jovian moons. The system is substantially modified from the terrestrial magnetosphere because the rapid rotation of Jupiter produces strong acceleration of heavy ion species such as O⁺ and S⁺ emanating from the Jovian moons. Because of this acceleration these heavy ions can dominate the energy and momentum transport within at least the inner magnetosphere and possibly much of the outer magnetosphere. Multi-fluid simulations are used to model the acceleration of Jovian heavy ions and their effect on the overall shape on the Jovian magnetosphere. We show how the presence of heavy ions enhances the equatorial current sheet, which modifies the overall shape of the magnetosphere. In addition, they produce local inhomogeneities in the velocity field that leads to locally enhanced field-aligned currents and accelerated particle populations. The mixing of these accelerated heavy ions with the solar wind plasma leads to distinct particle populations in the Jovian magnetosphere.

SM21A-0528 0830h POSTER

Solar Wind Asymmetries around magnetic anomalies at the Moon and Mars.

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Magnetic anomalies have been found on both the Moon and Mars, but unlike the Moon, the Martian atmosphere is thick enough to hold off the solar wind through thermal pressure, creating a bow shock. 3D fluid simulations show that magnetic anomalies are important in determining how the solar wind interacts with the Moon and Mars. When no substantial atmosphere is present, as in the case of the Moon, the magnetic anomalies can lead to the formation of a localized shock surface that produces asymmetric solar wind flow over the Moon. These asymmetries can be seen well tail of the Moon. In the case of Mars, where there is a thick atmosphere and distinct ionopause, the magnetic anomalies are still able to modify the solar wind flow and the interaction produces an increase in the scale height of the atmosphere opposite the anomalies and creates a magnetopause within the pre-existing bow shock. The importance of the higher order moments of the anomalous field is reduced in the case of Mars, as the interaction region is further from the source. Disturbances in the solar wind flow deep down the tail, and can be modulated by changes in the interplanetary magnetic field.

SM21A-0529 0830h POSTER

3D Boltzmann Simulation of the Io's Plasma Environment with Adaptive Mesh and Particle Refinement

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The global dynamics of the ionized and neutral components in the environment of Io plays an important role in the interaction of Jupiter's corotating magnetospheric plasma with Io [Combi et al., 2002; 1998; Kabin et al., 2001]. The stationary simulation of this problem was done in the MHD [Combi et al., 1998; Linker et al., 1998; Kabin et al., 2001] and the electrodynamic [Saur et al., 1999] approaches. In this report, we develop a method of kinetic ion-neutral simulation, which is based on a multiscale adaptive mesh, particle and algorithm refinement. This method employs the fluid description for electrons whereas for ions the drift-kinetic and particle approaches are used. This method takes into account charge-exchange and photoionization processes. The first results of such simulation of the dynamics of ions in the Io's environment are discussed in this report.

M R Combi et al., *J. Geophys. Res.*, **103**, 9071, 1998.M R Combi, T I Gombosi, K Kabin, *Atmospheres in the Solar System: Comparative Aeronomy. Geophys. Monograph Series*, **130**, 151, 2002.K Kabin et al., *Planetary and Space Sci.*, **49**, 337, 2001.J A Linker et al., *J. Geophys. Res.*, **103**(E9), 19867, 1998.J Saur et al., *J. Geophys. Res.*, **104**, 25105, 1999.

SM21A-0530 0830h POSTER

Characterization of Solar Wind Interaction With Magnetized Bodies

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Since the dawn of the space age, the magnetosphere has been studied extensively not only to understand the geospace environment but also how solar wind, or stellar winds in general, interact with magnetized bodies. Early theoretical investigations of solar wind interaction with magnetized asteroids suggested that in addition to a magnetospheric type interaction it was

possible that, instead, only a whistler wing would be generated. Recently, through 2-D global hybrid (fluid electrons, kinetic ions) simulations, we have demonstrated that depending on the magnetic dipole strength of a body its interaction with the solar wind can be even more diverse and that a variety of solutions exist. For example, in addition to a whistler wing it is possible for a magnetized asteroid to have a set of fast and slow magnetosonic wakes. In another type of solution, a fast magnetosonic wake is the dominant feature of the interaction region. Our studies have also demonstrated that depending on the magnetic field strength of a body, the size of the interaction region may be comparable or smaller than ion gyroradius and, as a result, kinetic motion of the ions has a profound influence on the global structure of the interaction region. We have found that a useful parameter in characterization of the interaction region is D_p , the distance from the body at which solar wind ram pressure is balanced by its magnetic pressure. In this presentation, we illustrate the transition of the interaction region from a single whistler wing to a full magnetospheric type interaction as D_p , normalized to ion inertial length, is increased from values less than 1 to over 100. Implication of these results for various bodies in the solar system is also discussed.

SM21A-0531 0830h POSTER

Global hybrid simulations of the magnetosphere: progress report

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The ultimate understanding of the magnetosphere requires resolving important small-scale kinetic processes while accounting for the global coupling and dynamics of the magnetosphere. This implies that kinetic global simulations are bound to play a very significant role in our further understanding of the magnetospheric system and that the development of appropriate simulation models is imperative. However, due to their computationally more intensive nature kinetic simulations have been applied sparingly to global modeling efforts. In this regard, the global hybrid simulation model (fluid electrons, kinetic ions) is the next natural step beyond MHD. With more advances in computer technology, it is natural to ask to what extent global hybrid simulations are now possible. We reexamine this issue in detail. As part of this presentation, we will discuss our latest advances in code development and show examples of the application of these new codes to the global magnetospheric problem. In order to quantify the progress in kinetic simulations, we have found it useful to define the parameter kinetic time T_k . T_k is defined as the number of minutes that it takes a global kinetic simulation to run an equivalent of 1 minute in the real magnetospheric time. The goal is to have the kinetic time as close to unity as possible. We will quantify the utility of global kinetic simulations by discussing the values of T_k based on the existing codes, and our new codes.

SM21A-0532 0830h POSTER

From a Weak to a Strong Comet — 3D Global Hybrid Simulation Studies

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Numerical simulation results for the solar wind interaction with a weak comet at different heliocentric distances are presented. The different features of the plasma environment, such as the structured cycloidal tail and non-linear Mach cones typical for weak comets and their relation to structures like shocklets, bow shock, diamagnetic cavity and the "classical" magnetotail formed at stronger comets are discussed. The detailed theoretical investigations of weakly outgassing bodies are of interest for the interpretation of measurements at Borelli and future data from comet Wirtanen, which serves as a typical example.

For this purpose a three dimensional hybrid code using curvilinear coordinates was developed. Some numerical techniques are briefly introduced.

SM21B MCC: Hall D Tuesday 0830h

Aurora and Auroral Processes II Posters (joint with SA)

Presiding: E J Lund, University of New Hampshire; E Donovan, University of Calgary

SM21B-0533 0830h POSTER

Dayside High Latitude Auroral Particle Acceleration Observed by the Cluster Satellites

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We investigate an event observed by the four Cluster satellites in the dayside high latitude auroral region around 80 LLat and 14MLT at an altitude of about about 5Re. The Cluster satellites were located in the auroral region for about 30 minutes, corresponding to several thousand km along the orbit. In this region, the magnetic field showed periodic perturbation of about 2 min., and the upward electron acceleration, usually located just beside the downward electron acceleration structures, had the same period. All Cluster satellites observed the periodic acceleration signatures, and hence, we expect that the spacecraft observed filament like auroral arc structures. Similar periodic structures of the electron acceleration and magnetic perturbations have often been observed in the dayside auroral acceleration region by the Cluster satellites. We discuss possible mechanisms to generate the periodic perturbations and their relationship to the auroral particle acceleration phenomena.

SM21B-0534 0830h POSTER

Statistical results on the occurrence frequency of auroral potential structures, upgoing ion beams and plasma density depletions as a function of altitude (5000-30000 km)

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In the acceleration region and possibly above, negative potential structures, upgoing ion beams and plasma density cavities are known to be associated with inverted-V electron precipitation and discrete auroral arcs at the conjugate footpoint in the ionosphere. Here

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