5-Oct-18

Extended Neutral Clouds

Highlighted papers are useful overview/review/summary

Date	Authors, title, reference	Summary
1976	Eviatar, Mekler, Coroniti, *Jovian sodium plasma, Ap. J., 205, 622*	Model of production, transport, loss of sodium neutral cloud. Discussion of sodium neutral atoms reaching out into the solar wind.
1980	Cheng – *Effects of Io's volcanoes on the Plasma torus and Jupiter's magnetosphere, Ap. J., 242, 812*	Assumes 100 ton/s of SO_2 escapes from Io w/ 10^6 s (12d) lifetime. Neutral cloud near Io interacts inward-moving energetic ions & electrons (CHEX, dissociation, ionization) Dissociation of SO2 neutral cloud produces more energetic O and S atoms which have larger orbits, with AJs in outer magnetosphere. Also CHEX of torus ions with SO_2 neutral cloud produces flux of escaping ENAs Re-ionization (photo) of extended neutral cloud and escaping ENAs leads to production of hot plasma in the outer magnetosphere. Predicts production of negative ions.
1981	Kirsh, Krimigis, Kohl, Keath – *Upper limits for x-ray and energetic neutral particle emission from Jupiter: Voyager 1 results, GRL, 8, 169*	Excess counts in Voyager 1 LECP at ~200 RJ upstream – estimated as (a) x-rays but seemed too high, (b) ENAs from CHEX of LECP-energy particles with neutrals in the IPT. Estimates flux of 10^{25} /s or 0.05% of torus production.
1984	Baker, Zwickl, Krimigis, Carbary, Acuna – *Energetic particle transport in the upstream region of Jupiter: Voyager results, JGR, 89, 3775*	Voyager 1 & 2 LECP bursts of >30 keV electrons, protons and heavy ions on dawn – pre-noon side, outside bow shock. Suggests escaping magnetospheric ions as well as re-ionization of escaping ENAs.
1984	Eviatar & Barbosa – *Jovian magnetospheric neutral wind and auroral precipitation flux, JGR, 89, 7398*	Estimates ENA flux from CHEX in IPT (70 km/s) that are then photoionized in the outer magnetosphere – diffusing inward, scattering in inner magnetosphere, to produce aurora. Also mentions source of interplanetary ENAs – with additional CHEX of energetic ions in the outer magnetosphere as source of LECP particles reported by Kirsh et al. 1981

1985	Krimigis, Zwickl, Baker – *Energetic ions upstream of Jupiter's bow shock, JGR, 90, 3947*	Voyager 1 & 2 LECP bursts of >30 keV electrons, protons and heavy ions on dawn – pre-noon side, outside bow shock. Suggests escaping magnetospheric particles with subsequent acceleration.
1986	Barbosa & Eviatar – *Planetary fast neutral emission and effects on the solar wind: A cometary exosphere analog, Ap.J., 310, 927*	Estimates production of fast neutrals from charge-exchange in the Io torus. Predicts 1-2 x 10^{28} s^{-1} escaping from jovian system. Argues they may be found upstream of the jovian system, where they provide significant energy – and ion cyclotron waves.
1990	Mendillo, Baumgardner, Flynn, Hughes – *The extended sodium nebula of Jupiter, Nature, 348, 312*	Detection of sodium neutrals extending to >400 RJ. Proposes CHEX production at Io's orbit. Shows disk flaring angle of 22°
1992	Mendillo, Flynn, Baumgardner, *Imaging observations of Jupiter's sodium magneto-nebula during the Ulysses encounter, Science, 257, 1510*	Feb 1992 observations suggested weaker torus and plasma source than 1989/90.
1993	Schreier et al. *Modeling the Europa plasma torus, JGR, 98, 21231*	Uses Voyager data to argue for a Europa plasma source (12%), enhanced oxygen ions, higher T. Develops physical chemistry model to suggest 5-10/cm^3 density of Europa ions, from source of 2 x 10^{27} s^{-1}
1994	Flynn, Mendillo & Baumgartner – *The jovian sodium nebula: Two years of groundbased observation, JGR, 99, 8403*	Observations 1990-92 when decreasing source rate anti-correlates with flaring angle (20°-27°) Minor E-W asymmetry, Io-phase angle variation not significant
1995	Hall et al. – *Detection of an oxygen atmosphere on Jupiter's moon Europa, Nature, 373, 677*	HST observations of O (1304 & 1356 A) Implies atmosphere of O_2 (10 pbar).
1999	Haggerty & Armstrong, *Observations of jovian upstream events by Ulysses, JGR, 104, 4629*	10s keV ions measured by Ulysses. Upstream 192 "events" claimed to be of jovian origin – "leakage model"
1999	Burger, Schneider, Wilson – *Galileo's close-up view of the Io sodium jet, GRL, 26, 3333*	Image of sodium jet from Io with Galileo camera.

2002	Krimigis et al. *A nebula of gases from Io surrounding Jupiter, Nature, 415, 994*	Cassini flyby of Jupiter 2000 MIMI detects ENAs coming from Europa region – 50-80 keV/nucleon, assumed to be hydrogen. 1-2 x 10^{26} s^{-1} spreading out upstream and suggesting source of heat when picked up in the solar wind. Predicts spherical disk of energetic neutrals.
2003	Lagg et al. *In situ observations of a neutral gas torus at Europa, GRL, 30, 1556*	GLL EPD measurements 6-20 RJ show depletion features, suggesting H+ charge exchange with neutral material coming from Europa. 20-50 neutrals cm^{-3} needed.
2003	Mauk et al. *Energetic neutral atoms from a trans-Europa gas torus at Jupiter, Nature, 421, 920*	ENA flux measured by Cassini MIMI. 50-80 keV. 10^{25} s^{-1} source
2004	Mauk et al. – *Energetic ion characteristics and neutral gas interactions in Jupiter's magnetosphere, JGR, 109, A09S12*	Voyager LECP observations of 50 keV to 50 MeV ions, including PA evidence of interaction w/ neutrals near Europa's orbit. Fluxes of ENAs from ~Europa orbit consistent with Cassini images indicate total gas population of ~10^{34} neutral particles.
2004	Mendillo, Wilson, Spencer, Stansberry – *Io's volcanic control of Jupiter's extended neutral clouds, Icarus, 170, 430*	Na data from 1989-1999 Correlation Na brightness w/ IR from Io, suggesting volcanic control. Change in shape of extended disk with activity.
2004	Burger, Johnson – *Europa's neutral cloud: Morphology and comparison to Io, Icarus, 171, 557*	Model of sodium cloud from Europa – as observed by Brown 2001. Produces a cloud that is very closely tied to Europa – strong variation with orbit phase (contrast to uniform H_2 cloud)
2005	Hansen, Shemansky, Hendrix – *Cassini UVIS observations of Europa's oxygen atmosphere and torus, Icarus, 176, 305*	Cassini UVIS (Jan 2001) detection of O_2 atmosphere of Europa, plus extended corona of atomic O. Density limited to <8 atoms/cc for O and O_2
2005	Takihashi, Misawa, Nosawa, Morioka, Okano, Sood – *Dynamic features of Io's extended sodium distributions, Icarus, 178, 346*	From Io to 400 RJ imaging of sodium extended cloud 1998-1999. System III longitude variations, Io phase modulation, East-West variations, Source estimate 1-4 x 10^{26} /s
2007	Mendillo, Laurent, Wilson, Baumgardner, Konrad, Karl – *The sources of sodium escaping from Io revealed by spectral high definition imaging, Nature, 448, 330*	Io source of Na cloud from CHEX and molecular recombination. Extends farther down tail than suggested by Galileo flyby observations.

2009	Yoneda, Kagitani, Okano, *Short-term variability of Jupiter's extended sodium nebula, Icarus, 204, 589*	Observations of extended Na cloud – May-June 2007. Variations with Io phase & East vs. West. Modeled with 2-D model.
2015	Yoneda, Kagitani, Tsuchiya, Sakanoi, Okano, Brightening event seen in observations of Jupiter's extended sodium nebula, *Icarus, 261*, 31-33	Na observations 2013-2015. Faint emissions except Feb-Mar 2015 when enhanced by a factor x3. Same as Hisaki torus event.
2016	Kollman, Paranicas, Clark, Roussos, Lagg, Krupp – *The vertical thickness of Jupiter's Europa gas torus from charged particle measurements, GRL, 43, 9425*	Galileo EPD-Composition Measurement system 100 keV -MeV range – separates ions by mass. C10, E11, E15, E19, C20, C21 ~130 eV protons PA minimum at 70° Modeled as CHEX of H^+ with H_2 neutral cloud to find 3° (H=1 RJ) height of neutral cloud, max. equatorial density of 260-410 cm^{-3} Implies (via Smyth & Marconi 2006) that O density 20-50 cm^{-3}
2017	Kollman et al. - *A heavy ion and proton radiation belt inside of Jupiter's rings, GRL, 44,*	Juno-JEDI (PJ1) ~830 keV ions close to PA>80° around C/A. Lack of electrons. Hard making sulfur ions, no electrons with CRAND. ENAs from Europa cloud electron-stripped in atmosphere.