List of Tables

2.1	List of 29 limb flares in the sample for the statistical study of imaging spectroscopy	10
3.1	Loop-top velocity and footpoint separation speed in the 2003-11-03 X3.9 flare	27
5.1	Correlations between various parameters of the conjugate footpoints in the 2003-10-29 X10 flare	67
5.2	Asymmetric characteristics of the conjugate footpoints in the 2003-10-29 X10 flare	73
7.1	Summary of cases in the combined Fokker-Planck & hydrodynamic simulation 1	45
8.1	Neupert effect test of simulation cases	64
9.1	Summary of cases in the decay phase simulation	68

List of Figures

1	Artistic view of <i>RHESSI</i> observing the Sun	iii
1.1	Schematic of a stochastic acceleration model and two examples from the 2003-11-03 X3.9 $\&$	
	2002-04-30 M1.4 flare	3
2.1	Distribution of heliographic location and peak count rate of the selected flares	10
2.2	<i>RHESSI</i> light curves of flare 2092002 (2002-09-20, M1.8)	12
2.3	PIXON images of flare 2092002 at different energies	13
2.4	νf_{ν} spectra of the loop-top and footpoint sources of flare 2092002	13
2.5	Light curves of the individual loop-top and footpoint sources in flare 2092002	14
2.6	RHESSI Light curves and source morphology of flare 2080327 (2002-08-03, X1.0)	15
2.7	HXR contours at different energies on a <i>TRACE</i> EUV image for flare 2080327	16
2.8	Light curves of individual loop-top and footpoint sources in flare 2080327	17
2.9	Images of flares 2082809 (2002-08-28, C6.6) and 2111410 (2002-11-14, C5.5)	18
2.10	Statistics of loop-top and footpoint spectral indexes	18
2.11	Histograms of footpoint to loop-top flux ratios at different times and energies	19
2.12	Statistics of <i>RHESSI</i> peak count rates	21
3.1	Flare (X3.9) of 2003-11-03: RHESSI and GOES light curves	24
3.2	Evolution of loop-top and footpoint source positions overlaid on SOHO MDI magnetogram	26
3.3	History of positions and spectral indexes of the loop-top and footpoint sources	28
3.4	Energy-dependent loop-top source structure and its correlation with HXR flux	$\frac{20}{29}$
0.1	Energy dependent loop top bource buildeare and his correlation with minit har	20
4.1	Flare (M1.4) of 2002-04-30: <i>RHESSI</i> & <i>GOES</i> light curves	35
4.2	PIXON images in different energy bands near the maximum of the main HXR peak	36
4.3	Energy-dependent <i>RHESSI</i> source structure, together with <i>SOHO</i> EIT & MDI images	38
4.4	Temporal exclusion of the source structure at different energies	
	remporal evolution of the source structure at different energies	40
4.5	History of the centroid heights and X-ray fluxes of the two coronal sources	$\begin{array}{c} 40\\ 41 \end{array}$
$\begin{array}{c} 4.5 \\ 4.6 \end{array}$	History of the centroid heights and X-ray fluxes of the two coronal sources	$ \begin{array}{l} 40 \\ 41 \\ 43 \end{array} $
$4.5 \\ 4.6 \\ 4.7$	History of the centroid heights and X-ray fluxes of the two coronal sources	40 41 43 45
$4.5 \\ 4.6 \\ 4.7 \\ 4.8$	History of the centroid heights and X-ray fluxes of the two coronal sources	$ \begin{array}{r} 40 \\ 41 \\ 43 \\ 45 \\ 47 \end{array} $
$\begin{array}{c} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \end{array}$	History of the centroid heights and X-ray fluxes of the two coronal sources	40 41 43 45 47 48
$ \begin{array}{r} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \\ 5.1 \\ \end{array} $	History of the centroid heights and X-ray fluxes of the two coronal sources	40 41 43 45 47 48 55
$ \begin{array}{r} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \\ 5.1 \\ 5.2 \\ \end{array} $	History of the centroid heights and X-ray fluxes of the two coronal sources Imaged spectra of the two coronal sources Imaged spectra of the two coronal sources Evolution of various spectroscopic quantities of the two coronal sources Schematic of the spatial variation of photon spectra hardness Schematic suggested by observations Flare (X10) of 2003-10-29: <i>RHESSI</i> and <i>GOES</i> light curves RHESSI 12-25 and 60-100 keV images at selected times	$ \begin{array}{r} 40\\ 41\\ 43\\ 45\\ 47\\ 48\\ 55\\ 57\\ \end{array} $
$\begin{array}{c} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \\ 5.1 \\ 5.2 \\ 5.3 \end{array}$	History of the centroid heights and X-ray fluxes of the two coronal sources Imaged spectra of the two coronal sources Imaged spectra of the two coronal sources Evolution of various spectroscopic quantities of the two coronal sources Schematic of the spatial variation of photon spectra hardness Schematic suggested by observations Flare (X10) of 2003-10-29: <i>RHESSI</i> and <i>GOES</i> light curves <i>RHESSI</i> 12-25 and 60-100 keV images at selected times CLEAN images in different energy bins <i>CLEAN</i> images in different energy bins	40 41 43 45 47 48 55 57 58
$\begin{array}{c} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \\ 5.1 \\ 5.2 \\ 5.3 \\ 5.4 \end{array}$	History of the centroid heights and X-ray fluxes of the two coronal sources Imaged spectra of the two coronal sources Imaged spectra of the two coronal sources Evolution of various spectroscopic quantities of the two coronal sources Schematic of the spatial variation of photon spectra hardness Schematic of the spatial variation of photon spectra hardness Schematic of the spatial variation of photon spectra hardness Schematic suggested by observations Flare (X10) of 2003-10-29: <i>RHESSI</i> and <i>GOES</i> light curves <i>RHESSI</i> 12-25 and 60-100 keV images at selected times CLEAN images in different energy bins Imaged spectra of the loop-top and two footpoint sources	$ \begin{array}{r} 40\\ 41\\ 43\\ 45\\ 47\\ 48\\ 55\\ 57\\ 58\\ 60\\ \end{array} $
$\begin{array}{c} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \\ 5.1 \\ 5.2 \\ 5.3 \\ 5.4 \\ 5.5 \end{array}$	History of the centroid heights and X-ray fluxes of the two coronal sources Imaged spectra of the two coronal sources Imaged spectra of the two coronal sources Evolution of various spectroscopic quantities of the two coronal sources Schematic of the spatial variation of photon spectra hardness Schematic of the spatial variation of photon spectra hardness Schematic of the spatial variation of photon spectra hardness Schematic spectroscopic quantities of the two coronal sources Flare (X10) of 2003-10-29: <i>RHESSI</i> and <i>GOES</i> light curves <i>RHESSI</i> 12-25 and 60-100 keV images at selected times CLEAN images in different energy bins Imaged spectra of the loop-top and two footpoint sources Evolution of spectroscopic parameters of the loop-top source Imaged source	$\begin{array}{c} 40 \\ 41 \\ 43 \\ 45 \\ 47 \\ 48 \\ 55 \\ 57 \\ 58 \\ 60 \\ 61 \\ \end{array}$
$\begin{array}{c} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \\ 5.1 \\ 5.2 \\ 5.3 \\ 5.4 \\ 5.5 \\ 5.6 \end{array}$	History of the centroid heights and X-ray fluxes of the two coronal sources Imaged spectra of the two coronal sources Evolution of various spectroscopic quantities of the two coronal sources Schematic of the spatial variation of photon spectra hardness Schematic of the spatial variation of photon spectra hardness Schematic spectroscopic quantities of the two coronal sources Flare (X10) of 2003-10-29: <i>RHESSI</i> and <i>GOES</i> light curves Schematic spectroscopic quantities of the spectra spectra hardness Flare (X10) of 2003-10-29: <i>RHESSI</i> and <i>GOES</i> light curves Schematic spectroscopic quantities at selected times CLEAN images in different energy bins Schematic spectroscopic parameters of the loop-top source Evolution of spectroscopic parameters of the loop-top source Schematic spectroscopic parameters of the loop-top source	$\begin{array}{c} 40 \\ 41 \\ 43 \\ 45 \\ 47 \\ 48 \\ 55 \\ 57 \\ 58 \\ 60 \\ 61 \\ 63 \\ \end{array}$
$\begin{array}{c} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \\ 5.1 \\ 5.2 \\ 5.3 \\ 5.4 \\ 5.5 \\ 5.6 \\ 5.7 \end{array}$	History of the centroid heights and X-ray fluxes of the two coronal sources Imaged spectra of the two coronal sources Imaged spectra of the two coronal sources Evolution of various spectroscopic quantities of the two coronal sources Schematic of the spatial variation of photon spectra hardness Schematic of the spatial variation of photon spectra hardness Schematic of the spatial variation of photon spectra hardness Schematic suggested by observations Schematic of the spatial variation of photon spectra hardness Schematic suggested by observations Scenario of magnetic reconnection and particle acceleration suggested by observations Scenario Flare (X10) of 2003-10-29: <i>RHESSI</i> and <i>GOES</i> light curves Scenario <i>RHESSI</i> 12-25 and 60-100 keV images at selected times Scenario CLEAN images in different energy bins Scenario Imaged spectra of the loop-top and two footpoint sources Scenario Evolution of spectroscopic parameters of the loop-top source Scenario Multiwavelength images overlaid with <i>RHESSI</i> contours and centroids Scenario Motions of <i>RHESSI</i> centroids of the loop-top and two footpoint sources Scenario	$\begin{array}{c} 40\\ 41\\ 43\\ 45\\ 47\\ 48\\ 55\\ 57\\ 58\\ 60\\ 61\\ 63\\ 65\\ \end{array}$
$\begin{array}{c} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \\ 5.1 \\ 5.2 \\ 5.3 \\ 5.4 \\ 5.5 \\ 5.6 \\ 5.7 \\ 5.8 \end{array}$	History of the centroid heights and X-ray fluxes of the two coronal sources Imaged spectra of the two coronal sources Imaged spectra of the two coronal sources Evolution of various spectroscopic quantities of the two coronal sources Schematic of the spatial variation of photon spectra hardness Schematic of the spatial variation of photon spectra hardness Schematic of the spatial variation of photon spectra hardness Schematic suggested by observations Scenario of magnetic reconnection and particle acceleration suggested by observations Scenario Flare (X10) of 2003-10-29: <i>RHESSI</i> and <i>GOES</i> light curves <i>RHESSI</i> 12-25 and 60-100 keV images at selected times CLEAN images in different energy bins Imaged spectra of the loop-top and two footpoint sources Evolution of spectroscopic parameters of the loop-top source Imaged spectra of the loop-top and two footpoint sources Multiwavelength images overlaid with <i>RHESSI</i> contours and centroids Imaged spectra of the loop-top and two footpoint sources Motions of <i>RHESSI</i> centroids of the loop-top and two footpoint sources Imaged spectra set the loop-top and two footpoint sources Multiwavelength images overlaid with <i>RHESSI</i> contours and centroids Imaged set the set the loop-top and two footpoint sources Motions of <i>RHESSI</i> centroids of the loop-top and two footpoint sources Imaged set the s	$\begin{array}{c} 40\\ 41\\ 43\\ 45\\ 47\\ 48\\ 55\\ 57\\ 58\\ 60\\ 61\\ 63\\ 65\\ 68\\ \end{array}$
$\begin{array}{r} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \\ 5.1 \\ 5.2 \\ 5.3 \\ 5.4 \\ 5.5 \\ 5.6 \\ 5.7 \\ 5.8 \\ 5.9 \end{array}$	History of the centroid heights and X-ray fluxes of the two coronal sources Imaged spectra of the two coronal sources Imaged spectra of the two coronal sources Evolution of various spectroscopic quantities of the two coronal sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources RHESSI 12-25 and 60-100 keV images at selected times Schematic second sources CLEAN images in different energy bins Schematic second sources Imaged spectra of the loop-top and two footpoint sources Schematic second sources Wultiwavelength images overlaid with RHESSI contours and centroids Schemati	$\begin{array}{c} 40\\ 41\\ 43\\ 45\\ 47\\ 48\\ 555\\ 57\\ 58\\ 60\\ 61\\ 63\\ 65\\ 68\\ 69\\ \end{array}$
$\begin{array}{r} 4.5 \\ 4.6 \\ 4.7 \\ 4.8 \\ 4.9 \\ 5.1 \\ 5.2 \\ 5.3 \\ 5.4 \\ 5.5 \\ 5.6 \\ 5.7 \\ 5.8 \\ 5.9 \\ 5.10 \end{array}$	History of the centroid heights and X-ray fluxes of the two coronal sources Imaged spectra of the two coronal sources Imaged spectra of the two coronal sources Evolution of various spectroscopic quantities of the two coronal sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic of the spatial variation of photon spectra hardness Schematic second sources Schematic Schematic second sources Schematic second sources Schematic second sources Schematic second sources Schematic second sources Schematic second sources Schematic second	$\begin{array}{c} 40\\ 41\\ 43\\ 45\\ 47\\ 48\\ 555\\ 57\\ 58\\ 60\\ 61\\ 63\\ 65\\ 68\\ 69\\ 76\\ \end{array}$

6.1	Flare (M1.7) of 2003-11-13: <i>RHESSI</i> and <i>GOES</i> light curves
6.2	Mosaic (energy-by-time) of CLEAN images
6.3	RHESSI images overlaid on SOHO EIT and MDI maps
6.4	Loop model and profiles of X-ray surface brightness $(\parallel, \perp \text{ to the loop})$
6.5	Evolution of X-ray profiles to the loop in three different energy bands
6.6	PIXON images at the impulsive peak in four different energy hands 94
6.7	Finally dependent X-ray profiles (\parallel to the loop) in three 24 s time intervals
6.8	Control of two belies of the loop at different energies
6.0	Centrold positions of the northern ball loop and to the loop
0.9 C 10	Centrol positions of the northern nan toop, and ± to the loop
0.10	Instory of source compactness and spectral parameters $\dots \dots \dots$
0.11	Breinsstrahung yield vs. electron spectral index for a low-energy cuton at $E_1 = 20 \text{ keV}$ 100
0.12	lest of the Neupert effect: various correlations
6.13	Spatially integrated spectra (νF_{ν}) for at three times
6.14	Averaged density profiles inferred along the loop at three times
71	Teal flow short for Dentiele (Felder Plenck) and Hudrodynamic (HD) and communication [19]
7.1	Initial state of the flare loop for the HD simulation
1.4	Inclar state of the flate loop for the TD simulation
1.3	HD evolution of various quantities for reference Case R
(.4	History of various quantities at 1 Mm from the acceleration region for Case R 12
7.5	Evolution of electron spectra at different locations for Case A
7.6	HD evolution of various quantities for Case A
7.7	Evolution of electron flux vs. depth at different energies for Case A
7.8	Evolution of photon spectra at different locations for Case A
7.9	Evolution of photon fluxes vs. depth at different energies for Case A
7.10	Evolution of electron spectra at different locations for Case B
7.11	Evolution of photon spectra at different locations for Case B
7.12	Evolution of electron & photon fluxes vs. depth at different energies for Case B
7.13	HD evolution of Case B
7.14	Evolution of electron & photon spectra at different locations for Case C
7.15	Evolution of electron & photon fluxes vs. depth at different energies for Case C
7.16	HD evolution of Case C
7.17	HD evolution of various quantities for Case D 14:
7.18	Electron & photon spectra and fluxes vs. depth for Case D
7.19	Comparison of history of various quantities for the five cases
8.1	Thermal bremsstrahlung emissivity vs. temperature
8.2	History of energy budget and X-ray emission for Case R
8.3	Consistency check of energy conservation for Case R
8.4	Neupert effect test for Case R at photon energy 1.6 keV
8.5	Neupert effect test for Case R at photon energy 6 keV
8.6	History of energy budget and X-ray emission for Case A
8.7	Neupert effect test for Case A at 1.6 keV 157
8.8	Neupert effect test for Case A at 6 keV 155
8.0	History of energy hudget and X-ray emission for Case B 15
8 10	Nouport affect toot for Case B at 1.6 keV
8 11	History of anorgy hudget and X ray emission for Case C
0.11	Instory of energy budget and X-ray emission for Case C
0.12	Neipert effect test for Gase C at 1.0 KeV
8.13	History of energy budget and A-ray emission for Case D
ð.14	Neupert enect test for Case D at 1.0 KeV
9.1	HD evolution of Case A
9.2	Energy budget evolution of Case A
9.3	Energy budget evolution of Case A: coronal and chromospheric portions
9.J	HD evolution of Case B 17
0.4 0.5	HD evolution of Case C 17
9.9 0.6	HD evolution of Case D 17^{-17}
5.0	

9.7	Energy budget evolution of Case D: full loop and coronal portion
9.8	Comparison of temperature, density, and X-ray emission profiles among Cases A-D 176
9.9	Comparison of decay of various quantities for Cases A-D
A.1	Ratio of piled-up to total counts during the 2003-11-13 M1.7 flare
A.2	Pileup severity during the 2003-10-29 X10 flare
A.3	Simulated <i>RHESSI</i> dynamic range
B.1	Cospatial of MDI magnetic anomaly and HXR footpoints in the 2003-10-29 X10 flare 203
B.2	Estimate of the loop leg density in the 2003-10-29 X10 flare
C.1	Incomplete gamma function $\psi(x)$ and its derivative
C.2	Energy loss rate due to Coulomb collisions in a warm background plasma 210
C.3	Energy loss and diffusion rates due to Coulomb collisions in a warm background plasma $\ . \ . \ 212$
C.4	Timescales of Coulomb energy loss and diffusion
C.5	Thermalization test of an injected Gaussian distribution of electrons

NOTE — Color versions of some figures can be found online at: http://sun.stanford.edu/~weiliu or http://hesperia.gsfc.nasa.gov/~weiliu