ncd $n = 23,426$ $nz = 156,026$

Preconditioner	nzlu	Time	MFlops
ILU0	156,026	0.5	0.2
ILUTH (10^{-2})	45,523	19.0	0.3
ILUTH (10^{-3})	154,747	19.2	0.7
ILUK (10)	233,882	40.3	14.8

Method	Preconditioner	Time	# it	$\|\|r\|\|$	$\|\|Ax\|\|$	Bk. Err.
GMRES ($m = 20$)	ILU0	248.2	500*	$0.45e-05$	$0.14e-05$	$0.29e-05$
	ILUTH (10^{-2})	211.9	500*	$0.46e-06$	$0.68e-06$	$0.48e-05$
	ILUTH (10^{-3})	253.7	500*	$0.19e-06$	$0.57e-07$	$0.35e-07$
	ILUK (10)	210.0	380	$0.98e-10$	$0.12e-08$	$0.71e-09$
BCG	ILU0	339.7	500*	$0.82e-01$	$0.22e-04$	$0.91e-03$
	ILUTH (10^{-2})	238.6	500*	$0.58e-03$	$0.77e-04$	$0.53e-03$
	ILUTH (10^{-3})	337.9	500*	$0.17e-01$	$0.52e-04$	$0.18e-03$
	ILUK (10)	404.5	500*	$0.46e-01$	$0.21e-05$	$0.11e-05$
CGS	ILU0	329.5	500*	$0.58e+03$	$0.25e-04$	$0.24e-03$
	ILUTH (10^{-2})	230.1	500*	$0.61e-01$	$0.47e-05$	$0.21e-04$
	ILUTH (10^{-3})	328.7	500*	$0.93e+05$	$0.12e-04$	$0.26e-04$
	ILUK (10)	54.6	69	$0.17e-11$	$0.57e-11$	$0.34e-11$
BCGStab	ILU0	45.9	69	$0.82e-10^{s}$	$0.20e-11$	$0.12e-11$
	ILUTH (10^{-2})	235.5	500*	$0.57e-06$	$0.42e-06$	$0.29e-06$
	ILUTH (10^{-3})	36.5	55	$0.50e-10^{s}$	$0.62e-11$	$0.37e-11$
	ILUK (10)	120.4	151	$0.63e-10^{s}$	$0.27e-09$	$0.16e-09$
QMR 2	ILU0	409.0	500*	$0.65e-05$	$0.29e-05$	$0.28e-04$
	ILUTH (10^{-2})	308.1	500*	$0.16e-04$	$0.95e-05$	$0.99e-04$
	ILUTH (10^{-3})	406.4	500*	$0.13e-07$	$0.90e-09$	$0.54e-09$
	ILUK (10)	476.5	500*	$0.54e-07$	$0.13e-05$	$0.80e-06$
QMR 3	ILU0	416.6	500*	$0.93e-08$	$0.43e-09$	$0.26e-09$
	ILUTH (10^{-2})	313.1	500*	$0.50e-05$	$0.25e-05$	$0.41e-04$
	ILUTH (10^{-3})	413.1	500*	$0.27e-05$	$0.10e-05$	$0.46e-05$
	ILUK (10)	482.5	500*	$0.18e-06$	$0.29e-05$	$0.62e-05$

SOR

ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.
1.0	$0.36e-04$	173.4	1,000*	$0.30e-06$	$0.18e-05$

Block SOR

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-4}$	1.0	$0.45e-10$	27.2	21	$0.23e-16$	$0.14e-16$	1
equal	1.0	$0.12e-04$	222.1	1,000*	$0.54e-07$	$0.35e-07$	0
other	1.0	$0.97e-04$	208.1	1,000*	$0.33e-06$	$0.30e-06$	2

IAD

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-4}$	1.0	$0.91e-11$	21.0	4	$0.38e-16$	$0.23e-16$	1
equal	1.0	failed (coupling matrix reducible)					
other	1.8	$0.99e-10$	182.3	580	$0.89e-12$	$0.54e-12$	2

Table A.9: Numerical Results for *ncd*.

ncd_gm4 $n = 23,426$ $nz = 156,026$

Preconditioner	nzlu	Time	MFlops
ILU0	156,026	0.5	0.2
ILUTH (10^{-2})	45,523	41.7	0.3
ILUTH (10^{-3})	403,855	42.9	1.9
ILUK (10)	226,244	104.8	50.5

Method	Preconditioner	Time	# it	$\|\|r\|\|$	$\|\|Ax\|\|$	Bk. Err.
GMRES ($m = 20$)	ILU0	177.3	360	$0.31e-10$	$0.15e-13$	$0.91e-14$
	ILUTH (10^{-2})	209.5	500*	$0.46e-06$	$0.68e-06$	$0.48e-05$
	ILUTH (10^{-3})	327.5	500*	$0.70e-06$	$0.10e-07$	$0.62e-08$
	ILUK (10)	141.3	260	$0.61e-11$	$0.46e-12$	$0.28e-12$
BCG	ILU0	331.3	500*	$0.32e-01$	$0.86e-05$	$0.79e-05$
	ILUTH (10^{-2})	251.2	500*	$0.25e-01$	$0.21e-02$	$0.27e-01$
	ILUTH (10^{-3})	514.9	500*	$0.15e-02$	$0.16e-06$	$0.10e-06$
	ILUK (10)	391.0	500*	$0.16e-02$	$0.37e-05$	$0.38e-05$
CGS	ILU0	38.4	59	$0.52e-10$	$0.25e-13$	$0.15e-13$
	ILUTH (10^{-2})	230.6	500*	$0.41e-02$	$0.47e-05$	$0.25e-04$
	ILUTH (10^{-3})	111.0	112	$0.89e-10$	$0.16e-12$	$0.98e-13$
	ILUK (10)	43.0	57	$0.77e-10$	$0.58e-11$	$0.35e-11$
BCGStab	ILU0	30.1	46	$0.36e-10^{s}$	$0.18e-13$	$0.11e-13$
	ILUTH (10^{-2})	234.7	500*	$0.42e-06$	$0.28e-06$	$0.18e-06$
	ILUTH (10^{-3})	53.3	53	$0.93e-10^{s}$	$0.52e-12$	$0.31e-12$
	ILUK (10)	49.9	65	$0.97e-10$	$0.20e-10$	$0.12e-10$
QMR 2	ILU0	410.7	500*	$0.43e-06$	$0.21e-09$	$0.13e-09$
	ILUTH (10^{-2})	305.8	500*	$0.83e-05$	$0.50e-05$	$0.85e-04$
	ILUTH (10^{-3})	583.4	500*	$0.82e-09$	$0.75e-11$	$0.45e-11$
	ILUK (10)	459.0	500*	$0.53e-07$	$0.40e-08$	$0.24e-08$
QMR 3	ILU0	405.3	500*	$0.13e-08$	$0.30e-06$	$0.25e-06$
	ILUTH (10^{-2})	308.8	500*	$0.10e-04$	$0.35e-05$	$0.59e-04$
	ILUTH (10^{-3})	591.6	500*	$0.81e-05$	$0.23e-06$	$0.18e-06$
	ILUK (10)	466.4	500*	$0.24e-04$	$0.83e-06$	$0.29e-05$

SOR

ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.
1.0	$0.48e-04$	157.7	1,000*	$0.39e-06$	$0.16e-05$

Block SOR

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-4}$	1.0	$0.45e-10$	24.0	21	$0.24e-16$	$0.14e-16$	1
equal	1.3	$0.98e-10$	39.0	53	$0.50e-14$	$0.30e-14$	0
other	1.0	$0.36e-07$	577.9	1,000*	$0.21e-10$	$0.13e-10$	2

IAD

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-4}$	1.0	$0.90e-11$	18.4	4	$0.38e-16$	$0.23e-16$	1
equal	1.4	$0.90e-10$	22.8	20	$0.16e-13$	$0.94e-14$	0
other	1.0	$0.13e-11$	12.8	6	$0.25e-16$	$0.15e-16$	2

Table A.10: Numerical Results for *ncd_gm4*.

ncd_alt1 $n = 23,426$ $nz = 156,026$

Preconditioner	nzlu	Time	MFlops
ILU0	156,026	0.5	0.2
ILUTH (10^{-2})	45,523	18.9	0.3
ILUTH (10^{-3})	89,732	19.1	0.4
ILUK (10)	234,088	30.1	4.1

Method	Preconditioner	Time	# it	$\|\|r\|\|$	$\|\|Ax\|\|$	Bk. Err.
GMRES ($m = 20$)	ILU0	248.6	500*	$0.31e-06$	$0.20e-07$	$0.12e-07$
	ILUTH (10^{-2})	207.0	500*	$0.15e-06$	$0.77e-07$	$0.10e-06$
	ILUTH (10^{-3})	224.0	500*	$0.13e-05$	$0.32e-06$	$0.24e-06$
	ILUK (10)	11.1	20	$0.98e-14$	$0.66e-14$	$0.33e-14$
BCG	ILU0	339.0	500*	$0.64e-03$	$0.74e-07$	$0.44e-07$
	ILUTH (10^{-2})	237.8	500*	$0.13e+05$	$0.17e-05$	$0.54e-04$
	ILUTH (10^{-3})	280.2	500*	$0.34e-06$	$0.19e-09$	$0.95e-10$
	ILUK (10)	9.0	11	$0.44e-11$	$0.60e-13$	$0.30e-13$
CGS	ILU0	328.9	500*	$0.16e+15$	$0.12e-05$	$0.52e-05$
	ILUTH (10^{-2})	230.2	500*	$0.14e+11$	$0.19e-05$	$0.58e-04$
	ILUTH (10^{-3})	271.2	500*	$0.18e+10$	$0.13e-05$	$0.62e-05$
	ILUK (10)	3.3	4	$0.62e-10$	$0.48e-16$	$0.24e-16$
BCGStab	ILU0	55.4	83	$0.49e-10^{s}$	$0.13e-13$	$0.63e-14$
	ILUTH (10^{-2})	236.6	500*	$0.21e-06$	$0.13e-07$	$0.70e-08$
	ILUTH (10^{-3})	65.3	117	$0.21e-10^{s}$	$0.93e-14$	$0.46e-14$
	ILUK (10)	3.3	4	$0.40e-10$	$0.47e-16$	$0.23e-16$
QMR 2	ILU0	408.8	500*	$0.13e-04$	$0.41e-05$	$0.15e-03$
	ILUTH (10^{-2})	308.9	500*	$0.80e-04$	$0.44e-05$	$0.18e-04$
	ILUTH (10^{-3})	347.0	500*	$0.80e-08$	$0.14e-11$	$0.72e-12$
	ILUK (10)	10.8	11	$0.43e-11$	$0.78e-13$	$0.39e-13$
QMR 3	ILU0	416.9	500*	$0.24e-05$	$0.30e-06$	$0.13e-05$
	ILUTH (10^{-2})	312.6	500*	$0.47e-05$	$0.17e-05$	$0.22e-05$
	ILUTH (10^{-3})	357.1	500*	$0.22e-05$	$0.17e-08$	$0.84e-09$
	ILUK (10)	15.7	16	$0.37e-10$	$0.31e-12$	$0.15e-12$

SOR

ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.
1.0	$0.39e-03$	167.7	1,000*	$0.80e-08$	$0.87e-08$

Block SOR

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.38e-11$	15.6	7	$0.48e-16$	$0.24e-16$	1
$\gamma = 10^{-5}$	1.0	$0.14e-10$	19.4	16	$0.41e-16$	$0.21e-16$	5
$\gamma = 10^{-4}$	1.0	$0.18e-10$	4.5	17	$0.39e-16$	$0.20e-16$	101
equal	1.0	$0.35e-03$	222.9	1,000*	$0.45e-07$	$0.71e-07$	0
other	1.0	$0.71e-10$	2.4	9	$0.78e-15$	$0.39e-15$	2

IAD

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.60e-11$	20.7	4	$0.48e-16$	$0.24e-16$	1
$\gamma = 10^{-5}$	1.0	$0.34e-11$	17.7	3	$0.48e-16$	$0.24e-16$	5
$\gamma = 10^{-4}$	1.0	$0.34e-11$	5.1	3	$0.48e-16$	$0.24e-16$	101
equal	1.0	$0.31e-05$	304.9	1,000*	$0.45e-08$	$0.22e-08$	0
other	1.0	$0.45e-10$	6.1	7	$0.31e-15$	$0.15e-15$	2

Table A.11: Numerical Results for *ncd_alt1*.

ncd_alt1_gm7 $n = 23,426$ $nz = 156,026$

Preconditioner	nzlu	Time	MFlops
ILU0	156,026	0.5	0.2
ILUTH (10^{-2})	45,522	41.5	0.3
ILUTH (10^{-3})	224,927	42.0	0.9
ILUK (10)	229,615	67.0	13.7

Method	Preconditioner	Time	# it	$\|\|r\|\|$	$\|\|Ax\|\|$	Bk. Err.
GMRES ($m = 20$)	ILU0	69.2	140	$0.75e-11$	$0.23e-17$	$0.11e-17$
	ILUTH (10^{-2})	200.4	500*	$0.15e-06$	$0.78e-07$	$0.99e-07$
	ILUTH (10^{-3})	259.5	500*	$0.86e-06$	$0.14e-09$	$0.71e-10$
	ILUK (10)	266.2	500*	$0.27e-07$	$0.67e-17$	$0.33e-17$
BCG	ILU0	326.9	500*	$0.12e-05$	$0.52e-09$	$0.26e-09$
	ILUTH (10^{-2})	232.9	500*	$0.35e+04$	$0.14e-04$	$0.67e-04$
	ILUTH (10^{-3})	150.6	200	$0.47e-10$	$0.17e-11$	$0.86e-12$
	ILUK (10)	386.0	500*	$0.68e-05$	$0.42e-12$	$0.21e-12$
CGS	ILU0	28.4	44	$0.87e-10$	$0.26e-16$	$0.13e-16$
	ILUTH (10^{-2})	226.4	500*	$0.28e+11$	$0.21e-05$	$0.63e-04$
	ILUTH (10^{-3})	364.0	500*	$0.65e+00$	$0.18e-07$	$0.92e-08$
	ILUK (10)	139.2	185	$0.87e-10$	$0.51e-16$	$0.26e-16$
BCGStab	ILU0	29.2	45	$0.73e-10^{s}$	$0.22e-16$	$0.11e-16$
	ILUTH (10^{-2})	231.4	500*	$0.18e-06$	$0.10e-07$	$0.56e-08$
	ILUTH (10^{-3})	42.5	57	$0.48e-10^{s}$	$0.49e-14$	$0.25e-14$
	ILUK (10)	300.6	395	$0.59e-10^{s}$	$0.11e-15$	$0.54e-16$
QMR 2	ILU0	401.1	500*	$0.12e-05$	$0.43e-11$	$0.22e-11$
	ILUTH (10^{-2})	303.6	500*	$0.35e-04$	$0.62e-05$	$0.17e-04$
	ILUTH (10^{-3})	447.5	500*	$0.68e-09$	$0.37e-11$	$0.18e-11$
	ILUK (10)	465.1	500*	$0.32e-04$	$0.16e-13$	$0.78e-14$
QMR 3	ILU0	406.9	500*	$0.62e-04$	$0.32e-08$	$0.16e-08$
	ILUTH (10^{-2})	306.8	500*	$0.52e-05$	$0.11e-05$	$0.11e-05$
	ILUTH (10^{-3})	452.1	500*	$0.11e-04$	$0.94e-08$	$0.48e-08$
	ILUK (10)	470.5	500*	$0.14e-04$	$0.74e-14$	$0.37e-14$

SOR

ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.
1.0	$0.34e-03$	159.4	1,000*	$0.61e-08$	$0.49e-08$

Block SOR

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.38e-11$	14.5	7	$0.48e-16$	$0.24e-16$	1
$\gamma = 10^{-5}$	1.0	$0.14e-10$	18.5	16	$0.41e-16$	$0.21e-16$	5
$\gamma = 10^{-4}$	1.0	$0.93e-10$	8.6	39	$0.15e-16$	$0.74e-17$	101
equal	1.0	$0.99e-10$	12.4	9	$0.21e-14$	$0.10e-14$	0
other	1.0	$0.57e-10$	7.5	2	$0.13e-15$	$0.64e-16$	2

IAD

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.60e-11$	18.6	4	$0.48e-16$	$0.24e-16$	1
$\gamma = 10^{-5}$	1.0	$0.34e-11$	15.8	3	$0.48e-16$	$0.24e-16$	5
$\gamma = 10^{-4}$	1.0	$0.34e-11$	7.2	3	$0.48e-16$	$0.24e-16$	101
equal	1.0	$0.26e-10$	11.0	3	$0.19e-14$	$0.94e-15$	0
other	1.0	$0.74e-11$	10.0	2	$0.27e-16$	$0.14e-16$	2

Table A.12: Numerical Results for *ncd_alt1_gm7*.

ncd_alt1_gm5 $n = 23,426$ $nz = 156,026$

Preconditioner	nzlu	Time	MFlops
ILU0	156,026	0.8	0.2
ILUTH (10^{-2})	45,522	41.7	0.3
ILUTH (10^{-3})	224,927	42.1	0.9
ILUK (10)	229,599	69.8	13.7

Method	Preconditioner	Time	# it	$\|\|r\|\|$	$\|\|Ax\|\|$	Bk. Err.
GMRES ($m = 20$)	ILU0	60.5	120	$0.41e-10$	$0.12e-16$	$0.59e-17$
	ILUTH (10^{-2})	200.6	500*	$0.15e-06$	$0.78e-07$	$0.99e-07$
	ILUTH (10^{-3})	259.2	500*	$0.86e-06$	$0.14e-09$	$0.71e-10$
	ILUK (10)	266.1	500*	$0.66e-07$	$0.21e-16$	$0.10e-16$
BCG	ILU0	327.9	500*	$0.94e-02$	$0.47e-08$	$0.24e-08$
	ILUTH (10^{-2})	232.2	500*	$0.31e+04$	$0.18e-05$	$0.54e-04$
	ILUTH (10^{-3})	161.2	215	$0.60e-10$	$0.15e-10$	$0.76e-11$
	ILUK (10)	386.6	500*	$0.52e+02$	$0.93e-12$	$0.46e-12$
CGS	ILU0	28.3	44	$0.88e-10$	$0.26e-16$	$0.13e-16$
	ILUTH (10^{-2})	225.9	500*	$0.81e+04$	$0.39e-05$	$0.82e-04$
	ILUTH (10^{-3})	366.1	500*	$0.56e-07$	$0.98e-13$	$0.49e-13$
	ILUK (10)	207.0	269	$0.34e-10$	$0.53e-16$	$0.26e-16$
BCGStab	ILU0	29.8	46	$0.73e-10^{s}$	$0.22e-16$	$0.11e-16$
	ILUTH (10^{-2})	235.3	500*	$0.29e-06$	$0.13e-07$	$0.86e-08$
	ILUTH (10^{-3})	42.6	58	$0.82e-11^{s}$	$0.85e-15$	$0.42e-15$
	ILUK (10)	154.5	203	$0.37e-10^{s}$	$0.16e-15$	$0.79e-16$
QMR 2	ILU0	399.6	500*	$0.53e-08$	$0.36e-11$	$0.18e-11$
	ILUTH (10^{-2})	304.0	500*	$0.31e-04$	$0.48e-05$	$0.13e-04$
	ILUTH (10^{-3})	184.2	206	$0.65e-10$	$0.30e-10$	$0.15e-10$
	ILUK (10)	467.4	500*	$0.25e-04$	$0.11e-13$	$0.53e-14$
QMR 3	ILU0	408.3	500*	$0.64e-04$	$0.33e-08$	$0.17e-08$
	ILUTH (10^{-2})	306.6	500*	$0.52e-05$	$0.11e-05$	$0.11e-05$
	ILUTH (10^{-3})	454.3	500*	$0.11e-04$	$0.11e-07$	$0.56e-08$
	ILUK (10)	466.1	500*	$0.18e-04$	$0.81e-14$	$0.41e-14$

SOR

ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.
1.0	$0.34e-03$	158.6	1,000*	$0.61e-08$	$0.49e-08$

Block SOR

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.38e-11$	14.6	7	$0.48e-16$	$0.24e-16$	1
$\gamma = 10^{-5}$	1.0	$0.14e-10$	18.5	16	$0.41e-16$	$0.21e-16$	5
$\gamma = 10^{-4}$	1.0	$0.93e-10$	8.4	39	$0.15e-16$	$0.74e-17$	101
equal	1.0	$0.71e-10$	10.2	6	$0.16e-15$	$0.82e-16$	0
other	1.0	$0.50e-11$	7.5	2	$0.11e-15$	$0.56e-16$	2

IAD

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.60e-11$	18.5	4	$0.48e-16$	$0.24e-16$	1
$\gamma = 10^{-5}$	1.0	$0.34e-11$	16.1	3	$0.48e-16$	$0.24e-16$	5
$\gamma = 10^{-4}$	1.0	$0.34e-11$	7.1	3	$0.48e-16$	$0.24e-16$	101
equal	1.0	$0.28e-11$	11.0	3	$0.43e-16$	$0.21e-16$	0
other	1.0	$0.74e-11$	10.2	2	$0.27e-16$	$0.14e-16$	2

Table A.13: Numerical Results for *ncd_alt1_gm5*.

ncd_alt1_gm4 $n = 23,426$ $nz = 156,026$

Preconditioner	nzlu	Time	MFlops
ILU0	165,026	0.8	0.2
ILUTH (10^{-2})	45,523	22.5	0.2
ILUTH (10^{-3})	360,452	23.3	1.5
ILUK (10)	232,567	36.2	5.6

Method	Preconditioner	Time	# it	$\|r\|$	$\|Ax\|$	Bk. Err.
GMRES ($m = 20$)	ILU0	250.0	500*	$0.11e-04$	$0.87e-12$	$0.43e-12$
	ILUTH (10^{-2})	199.3	500*	$0.15e-06$	$0.77e-07$	$0.10e-06$
	ILUTH (10^{-3})	299.2	500*	$0.84e-06$	$0.16e-09$	$0.80e-10$
	ILUK (10)	265.2	500*	$0.21e-04$	$0.22e-12$	$0.11e-12$
BCG	ILU0	157.7	243	$0.29e-10$	$0.77e-14$	$0.38e-14$
	ILUTH (10^{-2})	228.3	500*	$0.52e+03$	$0.65e-05$	$0.66e-04$
	ILUTH (10^{-3})	197.7	208	$0.84e-10$	$0.28e-10$	$0.14e-10$
	ILUK (10)	386.7	500*	$0.66e+00$	$0.12e-10$	$0.58e-11$
CGS	ILU0	320.3	500*	$0.23e-05$	$0.10e-15$	$0.51e-16$
	ILUTH (10^{-2})	224.2	500*	$0.10e+09$	$0.15e-05$	$0.50e-04$
	ILUTH (10^{-3})	465.8	500*	$0.98e+05$	$0.38e-06$	$0.86e-05$
	ILUK (10)	277.1	369	$0.80e-10$	$0.18e-16$	$0.91e-17$
BCGStab	ILU0	328.8	500*	$0.83e-08$	$0.22e-16$	$0.11e-16$
	ILUTH (10^{-2})	231.4	500*	$0.42e-06$	$0.17e-07$	$0.93e-08$
	ILUTH (10^{-3})	49.7	54	$0.62e-10^{s}$	$0.13e-13$	$0.66e-14$
	ILUK (10)	159.6	210	$0.65e-10^{s}$	$0.12e-16$	$9.59e-17$
QMR 2	ILU0	201.0	249	$0.95e-10$	$0.40e-14$	$0.20e-14$
	ILUTH (10^{-2})	301.3	500*	$0.51e-04$	$0.57e-05$	$0.19e-04$
	ILUTH (10^{-3})	353.7	500*	$0.46e-09$	$0.84e-11$	$0.42e-11$
	ILUK (10)	466.0	500*	$0.35e-03$	$0.13e-12$	$0.67e-13$
QMR 3	ILU0	406.5	500*	$0.46e-04$	$0.19e-11$	$0.96e-12$
	ILUTH (10^{-2})	277.7	500*	$0.16e-05$	$0.25e-05$	$0.28e-04$
	ILUTH (10^{-3})	563.7	500*	$0.16e-04$	$0.96e-08$	$0.48e-08$
	ILUK (10)	467.8	500*	$0.21e-05$	$0.57e-15$	$0.24e-15$

SOR

ω	$\|\Delta x\|$	Time	# it	$\|Ax\|$	Bk. Err.
1.0	$0.39e-03$	157.0	1,000*	$0.71e-08$	$0.64e-08$

Block SOR

Partition.	ω	$\|\Delta x\|$	Time	# it	$\|Ax\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.38e-11$	8.4	7	$0.48e-16$	$0.24e-16$	1
$\gamma = 10^{-5}$	1.0	$0.14e-10$	12.2	16	$0.41e-16$	$0.21e-16$	5
$\gamma = 10^{-4}$	1.0	$0.18e-10$	4.1	17	$0.39e-16$	$0.20e-16$	101
equal	1.0	$0.84e-10$	3.4	10	$0.86e-15$	$0.43e-15$	0
other	1.0	$0.36e-10$	1.6	2	$0.15e-17$	$0.73e-18$	2

IAD

Partition.	ω	$\|\Delta x\|$	Time	# it	$\|Ax\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.60e-11$	14.0	4	$0.48e-16$	$0.24e-16$	1
$\gamma = 10^{-5}$	1.0	$0.34e-11$	12.4	3	$0.48e-16$	$0.24e-16$	5
$\gamma = 10^{-4}$	1.0	$0.34e-11$	4.8	3	$0.48e-16$	$0.24e-16$	101
equal	1.0	$0.16e-10$	5.3	5	$0.82e-15$	$0.41e-15$	0
other	1.0	$0.15e-11$	4.3	2	$0.32e-16$	$0.16e-16$	2

Table A.14: Numerical Results for *ncd_alt1_gm4*.

ncd_alt2 $n = 23,426$ $nz = 156,026$

Preconditioner	nzlu	Time	MFlops
ILU0	156,026	0.5	0.2
ILUTH (10^{-2})	45,523	17.4	0.3
ILUTH (10^{-3})	154,747	17.7	0.7
ILUK (10)	234,073	45.3	18.6

Method	Preconditioner	Time	# it	$\|\|r\|\|$	$\|\|Ax\|\|$	Bk. Err.
GMRES ($m = 20$)	ILU0	269.4	500*	$0.18e-06$	$0.65e-08$	$0.47e-07$
	ILUTH (10^{-2})	221.0	500*	$0.21e-07$	$0.12e-07$	$0.21e-07$
	ILUTH (10^{-3})	267.3	500*	$0.48e-06$	$0.10e-06$	$0.13e-06$
	ILUK (10)	292.2	500*	$0.37e-09$	$0.66e-15$	$0.33e-15$
BCG	ILU0	342.2	500*	$0.12e+05$	$0.15e-04$	$0.45e-03$
	ILUTH (10^{-2})	251.4	500*	$0.24e+02$	$0.19e-02$	$0.72e-02$
	ILUTH (10^{-3})	340.0	500*	$0.36e-03$	$0.52e-06$	$0.10e-05$
	ILUK (10)	398.3	500*	$0.36e-01$	$0.35e-10$	$0.18e-10$
CGS	ILU0	335.5	500*	$0.74e+08$	$0.14e-04$	$0.92e-04$
	ILUTH (10^{-2})	250.1	500*	$0.58e-03$	$0.96e-05$	$0.98e-05$
	ILUTH (10^{-3})	335.3	500*	$0.28e+07$	$0.68e-06$	$0.13e-05$
	ILUK (10)	212.1	273	$0.30e-10$	$0.13e-17$	$0.65e-18$
BCGStab	ILU0	302.3	443	$0.60e-10^{s}$	$0.41e-12$	$0.20e-12$
	ILUTH (10^{-2})	257.6	500*	$0.66e-05$	$0.12e-08$	$0.60e-09$
	ILUTH (10^{-3})	125.0	183	$0.41e-10^{s}$	$0.12e-11$	$0.58e-12$
	ILUK (10)	396.0	500*	$0.61e-09$	$0.14e-16$	$0.73e-17$
QMR 2	ILU0	422.5	500*	$0.23e-05$	$0.39e-06$	$0.35e-05$
	ILUTH (10^{-2})	330.4	500*	$0.89e-05$	$0.28e-05$	$0.27e-04$
	ILUTH (10^{-3})	418.7	500*	$0.12e-05$	$0.46e-07$	$0.26e-07$
	ILUK (10)	477.0	500*	$0.62e-05$	$0.53e-11$	$0.27e-11$
QMR 3	ILU0	424.9	500*	$0.58e-05$	$0.20e-05$	$0.21e-04$
	ILUTH (10^{-2})	333.3	500*	$0.30e-05$	$0.18e-05$	$0.31e-04$
	ILUTH (10^{-3})	421.2	500*	$0.40e-05$	$0.45e-06$	$0.69e-06$
	ILUK (10)	479.7	500*	$0.50e-06$	$0.80e-12$	$0.40e-12$

SOR

ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.
1.0	$0.28e-03$	176.2	1,000*	$0.17e-07$	$0.17e-07$

Block SOR

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-8}$	1.0	$0.32e-02$	1995.9	100*	$0.63e-08$	$0.42e-08$	1
$\gamma = 10^{-7}$	1.0	$0.15e-10$	164.6	2	$0.24e-17$	$0.12e-17$	0
$\gamma = 10^{-6}$	1.0	$0.68e-10$	48.2	20	$0.13e-16$	$0.67e-17$	1
equal	1.0	$0.69e-10$	2.0	5	$9.32e-14$	$0.16e-14$	0
other	1.0	$0.24e-03$	207.6	1,000*	$0.18e-07$	$0.13e-07$	2

IAD

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-8}$	1.0	$0.32e-02$	1708.6	100*	$0.63e-08$	$0.42e-08$	1
$\gamma = 10^{-7}$	1.0	$0.22e-11$	169.7	2	$0.32e-17$	$0.16e-17$	0
$\gamma = 10^{-6}$	1.0	$0.19e-10$	36.6	3	$0.17e-17$	$0.85e-18$	1
equal	1.5	$0.87e-10$	72.7	220	$0.28e-14$	$0.14e-14$	0
other	1.6	$0.99e-10$	169.7	539	$0.13e-12$	$0.65e-13$	2

Table A.15: Numerical Results for *ncd_alt2*.

ncd_alt2_gm7 $n = 23,426$ $nz = 156,026$

Preconditioner	nzlu	Time	MFlops
ILU0	156,026	0.8	0.2
ILUTH (10^{-2})	55,133	43.6	0.3
ILUTH (10^{-3})	397,998	44.8	2.0
ILUK (10)	230,063	102.2	48.6

Method	Preconditioner	Time	# it	$\|\|r\|\|$	$\|\|Ax\|\|$	Bk. Err.
GMRES ($m = 20$)	ILU0	242.2	500*	$0.18e-03$	$0.30e-07$	$0.24e-06$
	ILUTH (10^{-2})	205.3	500*	$0.23e-07$	$0.13e-07$	$0.23e-07$
	ILUTH (10^{-3})	353.8	500*	$0.58e-06$	$0.13e-07$	$0.19e-07$
	ILUK (10)	266.9	500*	$0.49e-04$	$0.54e-08$	$0.27e-08$
BCG	ILU0	332.9	500*	$0.23e+01$	$0.13e-06$	$0.39e-06$
	ILUTH (10^{-2})	243.3	500*	$0.31e+02$	$0.24e-02$	$0.13e-01$
	ILUTH (10^{-3})	521.7	500*	$0.31e+04$	$0.11e-04$	$0.25e-04$
	ILUK (10)	392.6	500*	$0.10e-01$	$0.92e-09$	$0.46e-09$
CGS	ILU0	198.2	303	$0.72e-10$	$0.18e-15$	$0.89e-16$
	ILUTH (10^{-2})	238.7	500*	$0.22e-07$	$0.33e-07$	$0.17e-07$
	ILUTH (10^{-3})	187.9	187	$0.80e-10$	$0.44e-13$	$0.22e-13$
	ILUK (10)	382.3	500*	$0.55e+03$	$0.18e-05$	$0.92e-06$
BCGStab	ILU0	171.5	258	$0.77e-10^{s}$	$0.18e-15$	$0.90e-16$
	ILUTH (10^{-2})	246.7	500*	$0.30e-06$	$0.10e-08$	$0.52e-09$
	ILUTH (10^{-3})	215.8	214	$0.71e-10^{s}$	$0.40e-13$	$0.20e-13$
	ILUK (10)	237.6	304	$0.34e-10^{s}$	$0.36e-17$	$0.18e-17$
QMR 2	ILU0	398.9	500*	$0.20e-03$	$0.31e-07$	$0.85e-07$
	ILUTH (10^{-2})	309.9	500*	$0.91e-05$	$0.23e-05$	$0.30e-04$
	ILUTH (10^{-3})	575.2	500*	$0.89e-05$	$0.31e-07$	$0.18e-07$
	ILUK (10)	457.3	500*	$0.27e-03$	$0.15e-10$	$0.75e-11$
QMR 3	ILU0	403.8	500*	$0.73e-04$	$0.94e-07$	$0.64e-06$
	ILUTH (10^{-2})	312.3	500*	$0.13e-04$	$0.29e-05$	$0.11e-04$
	ILUTH (10^{-3})	583.2	500*	$0.12e-04$	$0.43e-06$	$0.57e-06$
	ILUK (10)	467.3	500*	$0.17e-04$	$0.16e-09$	$0.82e-10$

SOR

ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.
1.0	$0.86e-04$	155.4	1,000*	$0.47e-07$	$0.32e-06$

Block SOR

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.15e-10$	100.1	2	$0.24e-17$	$0.12e-17$	0
$\gamma = 10^{-6}$	1.0	$0.68e-10$	35.2	20	$0.13e-16$	$0.67e-17$	1
equal	1.0	$0.28e-05$	589.4	1,000*	$0.13e-08$	$0.65e-09$	0
other	1.0	$0.16e-05$	533.5	1,000*	$0.54e-09$	$0.27e-09$	2

IAD

Partition.	ω	$\|\|\Delta x\|\|$	Time	# it	$\|\|Ax\|\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.22e-11$	105.7	2	$0.32e-17$	$0.16e-17$	0
$\gamma = 10^{-6}$	1.0	$0.19e-10$	28.7	3	$0.17e-17$	$0.85e-18$	1
equal	1.0	$0.20e-03$	669.9	1,000*	$0.63e-07$	$0.37e-07$	1
other	1.0	$0.12e-02$	640.6	1,000*	$0.25e-06$	$0.20e-06$	2

Table A.16: Numerical Results for *ncd_alt2_gm7*.

ncd_alt2_gm6 $n = 23,426$ $nz = 156,026$

Preconditioner	nzlu	Time	MFlops
ILU0	156,026	0.8	0.2
ILUTH (10^{-2})	55,023	41.3	0.3
ILUTH (10^{-3})	414,292	42.7	2.1
ILUK (10)	231,189	97.6	48.4

Method	Preconditioner	Time	# it	$\|r\|$	$\|Ax\|$	Bk. Err.
GMRES ($m = 20$)	ILU0	242.1	500*	$0.26e-03$	$0.35e-07$	$0.30e-06$
	ILUTH (10^{-2})	205.1	500*	$0.23e-07$	$0.13e-07$	$0.23e-07$
	ILUTH (10^{-3})	318.7	500*	$0.65e-06$	$0.10e-07$	$0.13e-07$
	ILUK (10)	266.6	500*	$0.18e-04$	$0.39e-09$	$0.19e-09$
BCG	ILU0	331.7	500*	$0.12e+03$	$0.29e-06$	$0.22e-05$
	ILUTH (10^{-2})	244.7	500*	$0.71e+01$	$0.19e-02$	$0.34e-02$
	ILUTH (10^{-3})	527.3	500*	$0.47e+03$	$0.41e-05$	$0.14e-04$
	ILUK (10)	394.0	500*	$0.25e+01$	$0.10e-08$	$0.52e-09$
CGS	ILU0	327.3	500*	$0.29e-02$	$0.20e-07$	$0.11e-07$
	ILUTH (10^{-2})	237.6	500*	$0.14e-03$	$0.43e-05$	$0.36e-05$
	ILUTH (10^{-3})	508.0	500*	$0.87e-01$	$0.14e-05$	$0.58e-05$
	ILUK (10)	386.8	500*	$0.51e+03$	$0.27e-10$	$0.13e-10$
BCGStab	ILU0	80.0	120	$0.40e-10^{s}$	$0.40e-16$	$0.20e-16$
	ILUTH (10^{-2})	245.2	500*	$0.14e-06$	$0.22e-08$	$0.11e-08$
	ILUTH (10^{-3})	149.3	147	$0.30e-10$	$0.30e-13$	$0.15e-13$
	ILUK (10)	386.4	500*	$0.14e-07$	$0.12e-16$	$0.61e-17$
QMR 2	ILU0	398.0	500*	$0.31e-03$	$0.45e-07$	$0.37e-06$
	ILUTH (10^{-2})	308.9	500*	$0.15e-04$	$0.46e-05$	$0.61e-08$
	ILUTH (10^{-3})	587.3	500*	$0.13e-04$	$0.12e-06$	$0.62e-06$
	ILUK (10)	458.5	500*	$0.74e-02$	$0.63e-11$	$0.32e-11$
QMR 3	ILU0	403.6	500*	$0.88e-04$	$0.81e-06$	$0.50e-05$
	ILUTH (10^{-2})	313.8	500*	$0.24e-04$	$0.83e-06$	$0.82e-06$
	ILUTH (10^{-3})	594.7	500*	$0.87e-05$	$0.77e-07$	$0.37e-06$
	ILUK (10)	468.1	500*	$0.22e-04$	$0.19e-09$	$0.95e-10$

SOR

ω	$\|\Delta x\|$	Time	# it	$\|Ax\|$	Bk. Err.
1.0	$0.82e-04$	155.5	1,000*	$0.47e-07$	$0.32e-06$

Block SOR

Partition.	ω	$\|\Delta x\|$	Time	# it	$\|Ax\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.15e-10$	125.0	2	$0.24e-17$	$0.12e-17$	0
$\gamma = 10^{-6}$	1.0	$0.68e-10$	34.0	20	$0.13e-16$	$0.67e-17$	1
equal	1.4	$0.48e-10$	28.7	37	$0.61e-15$	$0.31e-15$	0
other	1.0	$0.72e-10$	7.3	2	$0.24e-17$	$0.12e-17$	2

IAD

Partition.	ω	$\|\Delta x\|$	Time	# it	$\|Ax\|$	Bk. Err.	# Bl.
$\gamma = 10^{-7}$	1.0	$0.22e-11$	130.7	2	$0.32e-17$	$0.16e-17$	0
$\gamma = 10^{-6}$	1.0	$0.19e-10$	32.6	3	$0.17e-17$	$0.85e-18$	1
equal	0.8	$0.87e-10$	20.8	18	$0.28e-13$	$0.14e-13$	0
other	1.0	$0.19e-12$	9.2	2	$0.24e-17$	$0.12e-17$	2

Table A.17: Numerical Results for *ncd_alt2_gm6*.