

TABLE I. The determined helicity amplitudes for the  $\gamma p \rightarrow N^*$  transition at resonance pole positions. The presented values follow the notation:  $A_{1/2,3/2} = \bar{A}_{1/2,3/2} \times e^{i\phi}$  with  $\phi$  taken to be in the range  $-90^\circ \leq \phi < 90^\circ$ . The units of  $\bar{A}_{1/2,3/2}$  and  $\phi$  are  $10^{-3} \text{ GeV}^{-1/2}$  and degree, respectively. Each resonance is specified by the isospin and spin-parity quantum numbers as well as the real part of the resonance pole mass.

Particle $J^P(L_{2I_2J})$	$\bar{A}_{1/2}$	$\phi$	$\bar{A}_{3/2}$	$\phi$
$N(1490)1/2^-(S_{11})$	160	8	-	-
$N(1652)1/2^-(S_{11})$	36	-28	-	-
$N(1376)1/2^+(P_{11})$	-40	-8	-	-
$N(1741)1/2^+(P_{11})$	-47	-24	-	-
$N(1708)3/2^+(P_{13})$	131	7	-33	12
$N(1765)3/2^+(P_{13})$	123	-11	-71	3
$N(1509)3/2^-(D_{13})$	-28	< 1	102	4
$N(1703)3/2^-(D_{13})$	13	50	31	-71
$N(1651)5/2^-(D_{15})$	8	19	49	-12
$N(1665)5/2^+(F_{15})$	-44	-11	60	-2
$\Delta(1597)1/2^-(S_{31})$	105	1	-	-
$\Delta(1713)1/2^-(S_{31})$	40	13	-	-
$\Delta(1857)1/2^+(P_{31})$	-1	-78	-	-
$\Delta(1212)3/2^+(P_{33})$	-134	-16	-257	-3
$\Delta(1733)3/2^+(P_{33})$	-48	63	-94	74
$\Delta(1577)3/2^-(D_{33})$	128	19	119	46
$\Delta(1911)5/2^-(D_{35})$	48	-22	11	-36
$\Delta(1767)5/2^+(F_{35})$	38	-7	-24	-80
$\Delta(1885)7/2^+(F_{37})$	-69	-14	-83	2

TABLE II. The isovector and isoscalar helicity amplitudes for  $\gamma N \rightarrow N^*$  are defined as  $A_\lambda^{T=1} = (A_\lambda^p - A_\lambda^n)$ , and  $A_\lambda^{T=0} = (A_\lambda^p + A_\lambda^n)$ , where  $A_\lambda^p$  and  $A_\lambda^n$  are the helicity amplitudes of  $\gamma p \rightarrow N^*$  and  $\gamma n \rightarrow N^*$ , respectively. See the caption of Table I for the notation of the table.

Particle $J^P(L_2I_2J)$	$\bar{A}_{1/2}^{T=1}$	$\phi$	$\bar{A}_{1/2}^{T=0}$	$\phi$	$\bar{A}_{3/2}^{T=1}$	$\phi$	$\bar{A}_{3/2}^{T=0}$	$\phi$
$N(1490)1/2^-(S_{11})$	136	11	26	-10	-	-	-	-
$N(1652)1/2^-(S_{11})$	19	-29	18	-28	-	-	-	-
$N(1376)1/2^+(P_{11})$	-68	-13	28	-21	-	-	-	-
$N(1741)1/2^+(P_{11})$	-120	-11	75	-3	-	-	-	-
$N(1708)3/2^+(P_{13})$	95	7	36	8	-9	68	-29	-2
$N(1765)3/2^+(P_{13})$	78	-10	45	-14	-55	4	-16	-2
$N(1509)3/2^-(D_{13})$	7	-2	-35	-1	106	4	-5	8
$N(1703)3/2^-(D_{13})$	20	-28	-22	-63	54	-61	-24	-48
$N(1651)5/2^-(D_{15})$	42	4	-34	1	44	-8	6	-37
$N(1665)5/2^+(F_{15})$	-39	-11	-5	-8	58	-3	2	18