Detecting Light-Gluino-Containing Hadrons

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When supersymmetry breaking produces only dimension-2 operators, gluino and photino masses are of order 1 GeV or less. The $g\tilde{g}$ bound state has mass 1.3–2.2 GeV and lifetime $\gtrsim 10^{-5}-10^{-10}$ s. This range of mass and lifetime is largely unconstrained because missing energy and beam dump techniques are ineffective. With only small modifications, upcoming K^0 decay experiments can study most of the interesting range. The lightest gluino-containing baryon ($uds\tilde{g}$) is long lived or stable; experiments to find it and the $uud\tilde{g}$ are also discussed. [S0031-9007(96)00088-9]

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Some supersymmetry (SUSY) breaking scenarios produce negligible tree-level gaugino masses and scalar trilinear couplings; consequently they have no "SUSY CP problem" [1]. Although massless at tree level, gauginos get calculable masses through radiative corrections from electroweak (gaugino, Higgsino-Higgs, and gauge boson) and top-stop loops. Evaluating these within the constrained parameter space leads to a gluino mass range $m_{\tilde{g}} \sim \frac{1}{10} - 1$ GeV and photino mass range $m_{\tilde{\gamma}} \sim \frac{1}{10} - 1\frac{1}{2}$ GeV. The lightest chargino has a mass less than m_W. The photino is an attractive dark matter candidate, with a correct abundance for parameters in the predicted ranges [2]. Because of the non-negligible mass of the photino compared to the glueball, prompt photinos [3] are not a useful signature for the light gluinos and the energy they carry [4,5]. Gluino masses less than about $1\frac{1}{2}$ GeV are largely unconstrained [5], although they would cause modifications in jet distributions and have other indirect effects. Consequences for squark and chargino searches are discussed in Ref. [6].

The gluino forms bound states with gluons and other gluinos, as well as with quarks and antiquarks in a color octet state. The lightest of these states, the spin-1/2 gluon-gluino bound state called R^0, should have a mass $\sim 1.3-2.2$ GeV [1,5]. Since the gluino is light, this state is approximately degenerate with a flavor singlet pseudoscalar comprised mainly of $\tilde{g}\tilde{g}$ [5]. Experimental evidence is now quite strong for an "extra" flavor singlet pseudoscalar at $\sim$1500 MeV [7,1], in addition to those which can be accommodated in ordinary QCD. The η' is identified with the pseudo Goldstone boson associated with the breaking of the chiral R symmetry of the nearly massless gluino [5]. The lightest R baryon is the flavor-singlet spin-0 $uds\tilde{g}$ bound state called S^0, whose mass should lie 0–1 GeV above that of the R^0. Higher lying R hadrons decay to the R^0 and S^0 via conventional strong or weak interactions. The rest of this paper is devoted to finding evidence for these R hadrons.

I shall assume here that photinos are responsible for the cold dark matter of the Universe. This fixes more exactly the mass of the photino and R^0 because in order to obtain the correct density of photinos, the ratio $r \equiv m_{R^0}/m_{\tilde{\gamma}}$ must fall between about $\sim$1.6 and 2 [2], which is in the range predicted on the basis of the gluino and photino mass calculations [1]. The lifetime of the R^0 is then [1] $\tau_{R^0} \gtrsim (10^{-10} - 10^{-7})[M_{sq}/100 \text{ GeV}]^4$ s for $1.4 < M_{R^0} < 2$ GeV. This can be comparable to the $K_L^0 - K_S^0$ lifetime range, if $M_{sq} \sim 100$ GeV. In Ref. [5] I discussed strategies for detecting or excluding the existence of an R^0 with a lifetime so long it cannot be detected by its decays. Here I discuss several approaches appropriate if the R^0 lifetime is in the $\sim 10^{-5} - 10^{-10}$ s range.

If R^0's exist, beams for rare K^0 decay and ϵ'/ϵ experiments would contain R^0's. The detectors designed to observe K^0 decays can be used to study R^0 decays. High-luminosity beams are produced at low $p_\perp$, so perturbative QCD cannot be used to determine the R^0 flux in the beam. The most important outstanding phenomenological problem in studying light gluinos is to develop reliable methods for estimating the R^0 production cross section in the low $p_\perp$ region. Here the ratio of R^0 to K_L^0 fluxes in a given beam at the production point is parametrized by $p10^{-4}$.

Two-body decays are suppressed by approximate C invariance of SUSY QCD because the π^0, η, and R^0 have $C = +1$ while the $\tilde{\gamma}$ has $C = -1$. C and P are presumably violated, because the superpartners of left and right chiral quarks need not be degenerate. Their mass splitting is a model-dependent aspect of SUSY breaking, so we take the branching fraction of R^0 into two- (three-) body final states to be a free parameter, b_2 (b_3). Decays such as $R^0 \rightarrow \tilde{\gamma}\rho^0$ are C allowed and included with three-body decays. Four and higher body decays are suppressed by phase space, so $b_2 + b_3 \approx 1$; therefore bounding both b_2 and b_3 can rule out R^0's. Measuring b_2/b_3 would give indirect information on the mass splitting between left and right squarks.

The most important three-body decay mode is $R^0 \rightarrow \pi^+\pi^-\tilde{\gamma}$. Since the R^0 is a flavor singlet and the $\tilde{\gamma}$ has photonlike couplings, the $\pi^+\pi^- : \pi^0\pi^0$ branching fractions are in the ratio 9:1. Because of phase space suppression, decays involving K's and η's can be neglected compared to the $\pi\pi\tilde{\gamma}$ final state. Thus $R^0 \rightarrow \pi^+\pi^-\tilde{\gamma}$ accounts for $\sim$90% of three-body decays. One can require $M(\pi^+\pi^-) > M_K$ to reduce background without a severe loss of signal: e.g., for $M_{R^0} = 1.7$ GeV and $r = 2$, 72% of the $R^0 \to \pi^+\pi^-\tilde{\gamma}$ decays would pass this cut. The branching fraction for decays meeting this cut is therefore $0.65b_3$.

The dominant two-body decay channel is $R^0 \to \pi^0\tilde{\gamma}$. Searching for this decay is much like searching for the decay $K_L^0 \to \pi^0\nu\overline{\nu}$. Fortunately, the two final states are readily distinguishable because a typical π^0 from R^0 decay has much larger $p_\perp$ than one from $K_L^0 \to \pi^0\nu\overline{\nu}$, for which $p_\perp^{\max} = 231$ MeV. Furthermore, the $p_\perp$ spectrum of the pion in a two-body decay exhibits the striking Jacobian peak at $p_\perp^{\max}$. The existing limit on $B\,(K_L^0 \to \pi^0\nu\overline{\nu})$ will be used below to obtain some weak constraints on the R^0 lifetime and production cross section. Future experiments with a good acceptance in the large $p_\perp$ region can place a much better limit.

Another interesting two-body decay is $R^0 \to \eta\tilde{\gamma}$. Since $m(\eta) = 547$ MeV $> m(K^0) = 498$ MeV, there would be very little background mimicking η's in a high-resolution, precision K^0-decay experiment. Detecting η's in the decay region of one of these experiments, e.g., via their $\pi^+\pi^-\pi^0$ or $\pi^0\pi^0\pi^0$ final states whose branching fractions are 0.23 and 0.32, would be strong circumstantial evidence for an R^0. With the preferred $\eta - \eta'$ mixing angle and assuming equal mass u and d squarks, the amplitude for $R^0 \to \eta\tilde{\gamma}$ is about half that for $R^0 \to \pi^0\tilde{\gamma}$. Thus for $M_{R^0} = 1.7$ GeV and $r = 1.6$ (2.0), $B(R^0 \to \tilde{\gamma}\eta) \approx 0.12b_2(0.17b_2)$, but drops rapidly for smaller M_{R^0}.

Even if the rate for $R^0 \to (\eta \to \pi^+\pi^-\pi^0)\tilde{\gamma}$ is only a few percent that of $R^0 \to \pi^0\tilde{\gamma}$, both final states may be comparably accessible because experiments to study the single π^0 require a Dalitz conversion to reduce background. A handful of events in both two-body final states, if the $p_\perp$ acceptance is complete, yields $p_\perp^{\max}$ for each channel, hence $m_{\tilde{\gamma}}$ and M_{R^0}. Determination of the ratio $m(R^0)/m_{\tilde{\gamma}}$ is important to confirm or refute the proposal [2] that relic photinos are responsible for the bulk of the missing matter of the Universe.

We can estimate the sensitivity of neutral kaon experiments to R^0's as follows. The number of decays of a particle with decay length $\lambda \equiv \langle\gamma\beta c\tau\rangle$, in a fiducial region extending from L to $L + l$, is

$$N = N_0(e^{-L/\lambda} - e^{-(L+l)/\lambda}), \tag{1}$$

where N_0 is the total number of particles leaving the production point. In typical K_L^0 experiments, such as Fermilab's E799 and the ϵ'/ϵ experiments KTeV and NA48 which are scheduled to begin running during 1996 at FNAL and CERN, $L \sim 120$ m, $l \sim 12-30$ m, and $L/\lambda_{K_L^0} \sim 0.08$, so $e^{-L/\lambda} - e^{-(L+l)/\lambda} \approx (l/\lambda)e^{-L/\lambda}$. Denote the number of reconstructed $R^0 \to \tilde{\gamma}X$ events by N_X^R and denote the number of reconstructed $K_L \to Y$ events by N_Y^K. Then defining $B(R^0 \to \tilde{\gamma}X) \equiv b_X^R 10^{-2}$ and $B(K_L \to Y) = b_Y^K 10^{-4}$, and idealizing the particles as having a narrow energy spread, Eq. (1) leads to

$$N_X^R \approx N_Y^K(p10^{-4})\left(\frac{b_X^R 10^{-2}}{b_Y^X 10^{-4}}\right)\left(\frac{\epsilon_X}{\epsilon_Y}\right)\frac{\langle\gamma\beta\tau\rangle_{K_L^0}}{\langle\gamma\beta\tau\rangle_{R^0}} \times \exp[-L/\langle\gamma\beta c\tau\rangle_{R^0}], \tag{2}$$

where ϵ_X and ϵ_Y are the efficiencies for reconstructing the final state particles X and Y, $\gamma = E/m$ is the relativistic time dilation factor, and $\beta = P/E$ will be taken to be 1 below. Letting $x \equiv \lambda_K/\lambda_{R^0} = \langle E_{K_L^0}\rangle m_{R^0}\tau_{K_L^0}/\langle E_{R^0}\rangle m_{K_L^0}\tau_{R^0}$, and introducing the "sensitivity function" $S(x) \equiv x\exp[-Lx/\lambda_{K_L^0}]$, Eq. (2) implies that an experiment with

$$S^{\lim} \equiv \frac{100b_Y^K}{pb_X^R}\,\frac{N_X^R}{N_Y^K}\,\frac{\epsilon_Y}{\epsilon_X} \tag{3}$$

will restrict x to be such that $S(x) \leq S^{\lim}$. Thus the sensitivity of various experiments with the same $L/\lambda_{K_L^0}$ can be directly compared by comparing their $S^{\lim}$ values. Figure 1 shows $S(x)$ for $L/\lambda_{K_L^0} \sim 0.08$. The qualitative features are as expected: An experiment with a large K_L flux ($N_Y^K/b_Y^K\epsilon_Y$) has a low $S^{\lim}$ and thus is sensitive to a large range of $x \approx 4\tau_{K_L^0}/\tau_{R^0}$. For shorter lifetimes (large x), the R^0's decay before reaching the fiducial region, while for longer lifetimes (small x) the probability of decay in the fiducial volume is too low for enough events to be seen.

Consider first the Fermilab E799 experiment, which obtained [8] a 90% C.l. limit $B(K_L^0 \to \pi^0\nu\overline{\nu} \lesssim 5.8 \times 10^{-5}$. In this case the R^0 final state X and the K_L final state Y both consist of a single π^0 and missing energy. Therefore ϵ_Y/ϵ_X is just the ratio of probabilities (which we will denote, respectively, f_K and f_R) for the π^0 to have P_t in the allowed range, $160 < P_t < 231$ GeV, in the two cases. Taking $B(R^0 \to \tilde{\gamma}\pi^0) \approx b_2$ and $B(K_L^0 \to \pi^0\nu\overline{\nu}) \leq 5.8 \times 10^{-5}$ [8] means $b_Y^R = b^2 10^2$ and $b_Y^K < 0.58$, so that we have

$$S_{E799}^{\lim} = 0.58f_K/pb_2f_R\,. \tag{4}$$

With the spectrum $d\Gamma/dE_{\pi^0}$ used in Ref. [8], $f_K = 0.5$. For $R^0 \to \pi^0\tilde{\gamma}, f_R = ([\sqrt{1-(160)^2} - \sqrt{1-(231)^2}]/P_\pi) \approx 0.02 - 0.03$, when $M_{R^0} = 1.4-2$ GeV and r is in the range 2.2–1.6. Taking $f_R = 0.025$ gives $S_{E799}^{\lim} = 11.6/pb_2$. The peak of the function on the left-hand side of Eq. (4) [see Fig. 1(a)] occurs for $x = L/\lambda_{K_L^0}$, which is ≈12.5. Using $x \approx 4\tau_{K_L^0}/\tau_{R^0}$, the peak sensitivity is for an R^0 lifetime of 2×10^{-8} s, for which the existing experimental bound on $K_L^0 \to \pi^0\nu\overline{\nu}$ yields a limit $pb_2 \leq 2.4$. Whether or not this is a

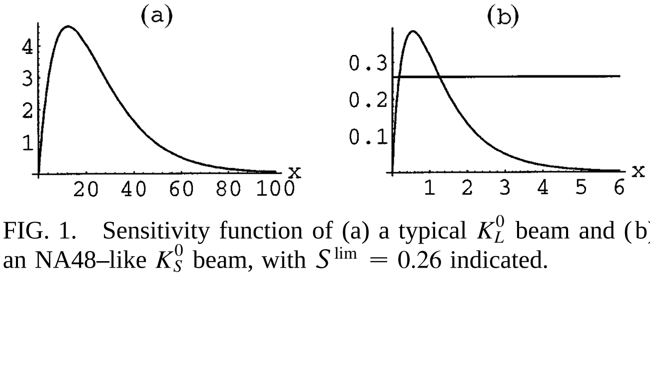

FIG. 1. Sensitivity function of (a) a typical K_L^0 beam and (b) an NA48–like K_S^0 beam, with $S^{\lim} = 0.26$ indicated.

significant restriction on R^0's can only be decided when reliable predications for (or at least reliable lower limits on) b_2 and the R^0 production cross section are in hand.

The next generation of K_L^0 experiments, KTeV and NA48, expect to collect $\sim N_Y^K = 5 \times 10^6$ reconstructed $K_L \to \pi^0\pi^0$ events. What sensitivity does this allow in searching for $R^0 \to \eta\tilde{\gamma}$, reconstructing the η from its $\pi^+\pi^-\pi^0$ decay? With a $\sim$5 MeV resolution in the $\pi^+\pi^-\pi^0$ invariant mass and negligible background between the K^0 and η, three reconstructed η's would be extremely exciting, so take $N_X^R = 3$. We know $B(K_L^0 \to \pi^0\pi^0) = 9 \times 10^{-4}$ and $B(\eta \to \pi^+\pi^-\pi^0) = 0.23$. Then taking $B(R^0 \to \eta\tilde{\gamma}) \approx 0.1 b_2$ means $b_Y^K = 9$ and $b_X^R \sim 2.3 b_2 \times 10^{-2}$. Thus $S^{\lim} = 2 \times 10^{-2}\epsilon_Y / p b_2 \epsilon_X$ where ϵ_Y is the efficiency for reconstructing the $\pi^0\pi^0$ final state of a K_L^0 decay and ϵ_X is the efficiency for reconstructing the $\pi^+\pi^-\pi^0$ final state of an η. ϵ_X needs to be determined by Monte Carlo simulation. If $pb_2 \sim 1$ and ϵ_X is good enough that, say, $S^{\lim} = 3 \times 10^{-2}/pb_2$, such a sensitivity allows the range $0.03 < x < 102$ to be probed. This corresponds to an ability to discover R^0's with a lifetime in the range $\sim 2 \times 10^{-9} - 0.7 \times 10^{-5}$ s. Note that in a rare K_L^0-decay experiment the flux of K_L^0's is much greater that for the ϵ'/ϵ experiments, so other things being equal a greater sensitivity can be achieved for a comparable acceptance. Unfortunately, E799 rejected the $\eta\tilde{\gamma}$ final state.

The use of an intense K_S^0 beam would allow shorter lifetimes to be probed. The FNAL E621 experiment designed to search for the CP violating $K_S^0 \to \pi^+\pi^-\pi^0$ decay had a high K_S^0 flux and a decay region close to the production target. However, its 20 MeV invariant mass resolution may be insufficient to adequately distinguish η's from K^0's. To estimate the sensitivity of, e.g., the NA48 detector we must return to Eq. (1), since for the planned K_S^0 beam $\lambda_{K_S^0} \approx L \approx l/2$. In this case $x_S \equiv \langle E_{K_S^0}\rangle m_{R^0}\tau_{K_S^0}/\langle E_{R^0}\rangle m_{K_S^0}\tau_{R^0} \approx 4\tau_{K_S^0}/\tau_{R^0}$ must satisfy

$$S^S(x_s) = (e^{-Lx_S/\lambda_{K_S^0}} - e^{-(L+l)x_S/\lambda_{K_S^0}}) < S^S_{\lim} \equiv (e^{-L/\lambda_{K_S^0}} - e^{-(L+l)/\lambda_{K_S^0}}) \times \frac{B(K_S^0 \to \pi^0\pi^0)}{b_X^R 10^{-2} p 10^{-4}} \frac{N_{R^{+-0}}}{N_{K_S^{00}}} \frac{\epsilon^{00}}{\epsilon^{+-0}} . \tag{5}$$

Taking the same production rate and efficiencies as before, and assuming $\sim 10^7$ reconstructed $K_S^0 \to \pi^0\pi^0$ decays gives $S^S_{\lim} = 0.26$. $S^S(x)$ is shown in Fig. 1(b). The sensitivity range is $0.19 < x_S < 1.3$ for $pb_2 = 1$; this corresponds to the lifetime range $3 \times 10^{-10} - 2 \times 10^{-9}$ s.

Thus for $pb_2 \approx 1$ the next generation of ϵ'/ϵ experiments will be able to see R^0's in the lifetime range $3 \times 10^{-10} - 0.7 \times 10^{-5}$ s. The greatest sensitivity is for $\tau_{R^0} = 2 \times 10^{-8}$ s; for this lifetime, values of pb_2 as small as $\sim 6 \times 10^{-3}$ should be accessible. For a given p, even better sensitivity is possible using the final state $\pi^+\pi^-\tilde{\gamma}$ with $m(\pi^+\pi^-) > m_K$, if $b_3 \geq b_2/8$. If we assume the background to this mode is low enough that observing $\sim$10 events with $m(\pi^+\pi^-) > m_K$ is sufficient for detection, the factor $N_X^R/b_X^R\epsilon_X$ appearing in Eq. (3) is reduced by the factor $(10/3)/[(0.65b_3)/(0.023b_2)]$. Thus $S^{\lim}$ is reduced by the factor $0.12b_2/b_3$ compared to the $R^0 \to \eta\tilde{\gamma}$ search. Hence, unless $p \ll 1$, the planned ϵ'/ϵ experiments will be sensitive to nearly the entire lifetime range of interest below $\sim 10^{-5}$ s independently of the relative importance of two- and three-body decays of the R^0.

Turning now to other R hadrons, the ground-state R baryon is the flavor singlet scalar $uds\tilde{g}$ bound state denoted S^0. On account of the very strong hyperfine attraction among the quarks in the flavor-singlet channel [9], its mass is about 210 ± 20 MeV lower than that of the lowest R nucleons. The mass of the S^0 is almost surely less than $m_\Lambda + m_{R_0}$, so it cannot decay through strong interactions. As long as m_{S^0} is less than $m_p + m_{R^0}$, the S^0 must decay to a photino rather than R^0, and would have an extremely long lifetime since its decay requires a flavor-changing-neutral-weak transition. The S^0 could even be stable, if $m_{S^0} - m_p - m_{e^-} < m_{\tilde{\gamma}}$ and R parity is a good quantum number. [If the baryon resonance known as the $\Lambda(1405)$ is a "cryptoexotic" flavor singlet bound state of $udsg$, one would expect the corresponding state with gluon replaced by a light gluino to be similar in mass. In this case the S^0 mass would be $\sim 1\frac{1}{2}$ GeV and the S^0 would be stable as long as the photino is heavier than $\sim$600 MeV, as it would be expected to be if photinos account for the relic dark matter.] This is not experimentally excluded [4,5] because the S^0 probably does not bind to nuclei. The two-pion-exchange force, which is attractive between nucleons, is repulsive between S^0 and nucleons because the mass of the intermediate R_Λ or R_Σ is much larger than that of the S^0.

If the S^0 is stable, it provides a possible explanation for the several very high energy cosmic ray events which have been recently observed [10]. Greisen-Zatsepin-Kuzmin (GZK) pointed out [11] that the cross section for proton scattering from the cosmic microwave background radiation is very large for energies above $\sim 10^{20}$ eV, because at such energies the $\Delta(1230)$ resonance is excited. If cosmic ray protons are observed with larger energies than the GZK bound they evidently originated within about 30 Mpc of our Galaxy. Since there are no good candidates for ultrahigh energy cosmic ray sources that close, the observed events with $E \sim 3 \times 10^{20}$ eV [10] have produced a puzzle for astrophysics. However, the threshold for producing a resonance of mass M^* in $\gamma(2.7\text{ Kelvin}) + S^0$ collisions is a factor $m_{S^0}/(M^* - m_{S^0})/m_p(m_\Delta - m_p)$ larger than for $\gamma(2.7\text{ Kelvin}) + p$ collisions. Taking $m_{R^0} = 1.7$ GeV, $m_{\tilde{\gamma}}$ must lie in the range 0.8–1.1 GeV to account for the relic dark matter. If $m_{S^0} \approx m_p + m_{\tilde{\gamma}}$, we have $m_{S^0} \sim 1.8 - 2.1$ GeV. Since the photon couples as a flavor octet, the resonances excited in $S^0\gamma$ collisions are flavor octets. Since the S^0 has spin 0, only a spin-1 R_Λ or R_Σ can be produced without an angular momentum barrier. There are two R-baryon flavor octets with $J = 1$, one with total quark spin $3/2$ and the other with total quark spin $1/2$, like the S^0. Neglecting the mixing between these states which is small, their masses are about 385–460 and 815–890 MeV heavier than the S^0, respectively [9]. Thus the GZK bound is increased by a factor of 2.4–6.5, depending on which R hyperons are strongly coupled to the γS^0 system. Therefore, if S^0's are stable, they naturally increase the GZK bound enough to be compatible with the extremely high energy cosmic rays reported in [10] and references therein.

The S^0 can be produced via a reaction such as $Kp \to R^0 S^0 + X$, or can be produced via decay of a higher mass R baryon such as an R proton produced in $pp \to R_p R_p + X$. In an intense proton beam at relatively low energy, the latter reaction is likely to be the most efficient mechanism for producing S^0's, as it minimizes the production of "extra" mass. Measuring a neutral particle's velocity by time of flight and its kinetic energy in a calorimeter determines its mass via $KE = m(1/\sqrt{1-\beta^2} - 1)$. Using this technique at FNAL, Gustafson *et al.* [12] put limits on the production of stable neutral particles, but was limited to masses above 2 GeV because of neutron background. At Brookhaven AGS energy the production cross section is lower, but pair production of S^0's probably dominates associated production of S^0-R^0 and production of R^0 pairs, because this increases the phase space. Demanding events in which two long-lived neutrals yield the same value of m suppresses neutron background. Also, at low energy the calorimetric determination of the S^0 kinetic energy is not smeared by conversion to R^0 because of the $t_{\min}$ required for a reaction like $S^0 N \to R^0 + \Lambda + N' + X$. Systematic errors in the calorimetry due to the S^0 cross section possibly differing from the neutron cross section should be considered.

If the R^0 is too long lived to be found via anomalous decays in kaon beams and the S^0 cannot be discriminated from a neutron, a dedicated experiment studying two-body reactions of the type $R^0 + N \to K^{+,0} + S^0$ could be done. In principle, using time of flight, calorimetry, and rescattering, the kinematics could be overconstrained allowing measurement of the R^0 and S^0 masses.

Light R hadrons other than the R^0 and S^0 will decay, most via the strong interactions, into one of these. However, since the lightest R nucleons are only about 210 ± 20 MeV heavier than the S^0, they would decay weakly, mainly to $S^0\pi$. (The R_{Ω^-} may also have only weak decays, to $R_\Xi + \pi$ or $R_\Sigma + K$, with the R_Ξ or R_Σ decaying strongly to $S^0 K$ or $S^0\pi$, respectively. Its mass should be roughly 940 MeV $[= m_{\Omega^-} - m_N + 210$ MeV$]$ greater than the S^0 mass.) R-nucleon lifetimes should be of order 2×10^{-11}–2×10^{-10} s, by scaling the rates for the analog weak decays $\Sigma' \to n\pi^-$, $\Lambda^- \to p\pi^-$, and $\Xi^- \to \Lambda\pi^-$ by phase space. Existing experimental limits [5] are poor in the lifetime region and kinematics of interest. Silicon microstrip detectors developed for charm studies are optimized for the lifetime range $(0.2-1.0) \times 10^{-12}$ s. Moreover, unlike ordinary hyperon decay, there is at most one charged particle in the final state, except for rare decay modes. In order to distinguish the decay $R_p \to S^0\pi^+$ from the much more abundant background such as $\Sigma^+ \to n\pi^+$, which has a similar energy release, one could rescatter the final neutral in order to get its direction. Then with sufficiently accurate knowledge of the momentum of the initial charged beam and the momentum (and identity) of the final pion, one has enough constraints to determine the masses of the initial and final baryons. The feasibility of such an experiment is worth investigating. Even without the ability to fully reconstruct the events, with sufficiently good momentum resolution on the initial and final charged particles, one could search for events which are not consistent with the kinematics of known processes such as $\Sigma^+ \to \pi^+ n$, and then see if they are consistent with two-body decay expected here.

In summary, planned K^0 experiments can be used to explore most of the interesting region of R^0 lifetime ($\sim 10^{-5}$–10^{-10} s) and determine the R^0 and photino masses. Experiments to study light-gluino-containing baryons have also been discussed.

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