CHAPTER 6

110

PSR 1854+00: A PULSAR NEAR THE SNR W44

The Ooty pulsar-search observations described in
The Ooty pulsar-search observations described in
On 5.4 detected a pulsar, PSR1854+00, in angular
mity to the SNP W44 As the initial estimate of the DM Section 5.4 detected a pulsar, PSR1854+00, in angular CHAPTER 6

PSR 1854+00: A PULSAR NEAR THE SNR W44

The Ooty pulsar-search observations described in

Section 5.4 detected a pulsar, PSR1854+00, in angular

proximity to the SNR W44. As the initial estimate of the DM

of th PSR 1854+00: A PULSAR NEAR THE SNR W44
The Ooty pulsar-search observations described in
Section 5.4 detected a pulsar, PSR1854+00, in angular
proximity to the SNR W44. As the initial estimate of the DM
of the pulsar was co the SNR, it became a priority to improve the measured accuracy of the dispersion measure and the pulsar position, of the pulsar was consistent with the estimated distance of
the SNR, it became a priority to improve the measured
accuracy of the dispersion measure and the pulsar position,
and also to get an estimate of its age. In this Section 5.4 detected a pulsar, PSR1854+00, in angular
proximity to the SNR W44. As the initial estimate of the DM
of the pulsar was consistent with the estimated distance of
the SNR, it became a priority to improve the mea results obtained will be described. Although a radio shell, W44 has an unusual X-ray morphology with bright central of the pursar was consistent with the estimated distance of
the SNR, it became a priority to improve the measured
accuracy of the dispersion measure and the pulsar position,
and also to get an estimate of its age. In this and also to get an estimate of its age. In this Chapter, the
observations performed to achieve these and the
results obtained will be described. Although a radio shell,
W44 has an unusual X-ray morphology with bright centr and also to get an estimate of its age. In this Chapter, the
observations performed to achieve these and the
results obtained will be described. Although a radio shell,
w44 has an unusual X-ray morphology with bright centr results obtained will be described. Although a radio shell,
W44 has an unusual X-ray morphology with bright central
emission and an absence of shell structure. The close
agreement between the distances derived for the SNR an expanding HI shell around the SNR, and its possible emission and an absence of shell structure. The close
agreement between the distances derived for the SNR and
the pulsar will be highlighted and the mass estimated for
the SNR from X-ray observations discussed. The presenc considered. NR from X-ray observations discussed. The presence of
panding HI shell around the SNR, and its possible
ionship with the objects in this region, will also be
dered.
THE TIMING OF PSR 1854+00
The period of a pulsar, its tim

6.1 THE TIMING OF PSR 1854+00

position of the object can all be obtained from observations of the arrival times of its pulses. The pulse arrival times considered.

6.1 THE TIMING OF PSR 1854+00

The period of a pulsar, its time derivative and the

position of the object can all be obtained from observations

of the arrival times of its pulses. The pulse arrival times

ha secular term, can be predicted using a mathematical model, The period of a pulsar, its time derivative and the
position of the object can all be obtained from observations
of the arrival times of its pulses. The pulse arrival times
have two components. The first, collectively call

11
random walk of pulsar phases (Manchester & Taylor <mark>1977).</mark>
The second term manifests itself as a wandering of pulsar 11
The second term manifests itself as a wandering of pulsar
The second term manifests itself as a wandering of pulsar
phases with excursion for various time scales having a range phases with excursion for various time scales having a range of amplitudes. The dominant component of this wandering is The second term manifests itself as a wandering of pulsar
phases with excursion for various time scales having a range
of amplitudes. The dominant component of this wandering is
too small to be noticed in our data and will the following discussion. s with excursion for various time scales having a range
plitudes. The dominant component of this wandering is
mall to be noticed in our data and will be neglected in
ollowing discussion.
For a given pulsar, the arrival-tim be noticed in our data and will be neglected in
discussion.
given pulsar, the arrival-time phases of the
solar-system barycentre are given by
 $\phi(t)=\phi(0)+\Omega(t-t_0)+(\frac{1}{2})\dot{\Omega}(t-t_0)^2$ (6.1)
expression, $\theta(0)$ refers to the ph

pulse at the solar-system barycentre are given by

$$
\phi(t) = \phi(0) + \Omega(t - t_0) + (\frac{1}{2})\dot{\Omega}(t - t_0)^2
$$
\n(6.1)

Ollowing discussion.

For a given pulsar, the arrival-time phases of the

at the solar-system barycentre are given by
 $\phi(t)=\phi(0)+\Omega(t-t_0)+(\frac{1}{2})\dot{\Omega}(t-t_0)^2$ (6.1)

In this expression, $\theta(0)$ refers to the phase value

red For a given pulsar, the arrival-time phases of the
pulse at the solar-system barycentre are given by
 $\phi(t)=\phi(0)+\hat{u}(t-t_0)+(\frac{1}{2})\hat{u}(t-t_0)^2$ (6.1)
In this expression, $\theta(0)$ refers to the phase value
measured at the refe For a given pulsar, the arrival-time phases of the
pulse at the solar-system barycentre are given by
 $\phi(t)=\phi(0)+\hat{\Omega}(t-t_0)+(\frac{1}{2})\hat{\Omega}(t-t_0)^2$ (6.1)
In this expression, $\theta(0)$ refers to the phase value
measured at the refe pulse at the solar-system barycentre are given by
 $\phi(t)=\phi(0)+\hat{u}(t-t_0)+(\frac{1}{2})\hat{u}(t-t_0)^2$ (6.1)

In this expression, $\theta(0)$ refers to the phase value

measured at the reference time, t_o and $\hat{u}(0)$ is the

angular f $\phi(t)=\phi(0)+\hat{\Omega}(t-t_0)+(\frac{1}{2})\hat{\Omega}(t-t_0)^2$ (6.1)

In this expression, $\theta(0)$ refers to the phase value

measured at the reference time, t_0 and $\hat{\Omega}(0)$ is the

angular frequency of the pulsar at time t_0 . However,

fo $\phi(t)=\phi(0)+\Omega(t-t_0)+(\frac{1}{2})\dot{\Omega}(t-t_0)^2$ (6.1)

In this expression, $\theta(0)$ refers to the phase value

measured at the reference time, t_0 and $\Omega(0)$ is the

angular frequency of the pulsar at time t_0 . However,

for a t In this expression, $\theta(0)$ refers to the phase value
measured at the reference time, t_0 and $\Omega(0)$ is the
angular frequency of the pulsar at time t_0 . However,
for a terrestial observer, the arrival-time phase of a rn chis expression, $v(v)$ refers to the phase value
measured at the reference time, t_0 and $\Omega(0)$ is the
angular frequency of the pulsar at time t_0 . However,
for a terrestial observer, the arrival-time phase of a
p the modulated by both the rotation of the Earth and
the orbital motion of the farth and
the orbital motion of the Earth around the Sun. The
modulation of the arrival time due to terrestial
rotation can have an amplitude o for a terrestial observer, the arrival-time base of a
pulse is modulated by both the rotation of the Earth and
the orbital motion of the Earth around the Sun. The
modulation of the arrival time due to terrestial
rotation the orbital motion of the Earth around the Sun. The
modulation of the arrival time due to terrestial
rotation can have an amplitude of about 20 msec, while
the modulation caused by the orbital motion of the Earth
is expect modulations are easily removed from the data. Assuming that modulation of the arrival time due to terrestial
rotation can have an amplitude of about 20 msec, while
the modulation caused by the orbital motion of the Earth
is expected to be about 500.cos sec, λ being the
ecliptic the modulation caused by the orbital motion of the Earth
is expected to be about 500.cos sec, λ being the
ecliptic latitude of the pulsar. The effect of the above
modulations are easily removed from the data. Assuming pulse-arrival time by

 δt _C = A. δ λ Cos(ωt- β)sin λ +A. $\delta\beta$.sin(ωt- β) cos λ (6.2)

where λ and β are respectively the ecliptic longitude and
latitude of the pulsar, A is the light travel time from the
Sun, to the Earth and 0 is the orbital angular, velocity of where λ and β are respectively the ecliptic longitude and
latitude of the pulsar, A is the light travel time from the
Sun to the Earth and ω is the orbital angular velocity of Sun to the Earth and ω is the orbital angular velocity of where λ and β are respectively the ecliptic longitude
latitude of the pulsar, A is the light travel time from the
sun to the Earth and ω is the orbital angular velocity of
the Earth (Smith, 1977). Thus an inaccur Where λ and β are respectively the ecliptic longitude
latitude of the pulsar, A is the light travel time from the
Sun to the Earth and ω is the orbital angular velocity of
the Earth (Smith, 1977). Thus an inaccur where λ and β are respectively the ecliptic longitude and
latitude of the pulsar, A is the light travel time from the
sun to the Earth and ω is the orbital angular velocity of
the Earth (Smith, 1977). Thus an ina where λ and β are respectively the ecliptic longitude
latitude of the pulsar, A is the light travel time from the
Sun to the Earth and ω is the orbital angular velocity of
the Earth (Smith, 1977). Thus an inaccur Numere A and β are respectively the ecriptic longitude
latitude of the pulsar, A is the light travel time from the
sun to the Earth and ω is the orbital angular velocity of
the Earth (Smith, 1977). Thus an inaccurac parameters of a pulsar is dependent on the initial accuracy of a few pulse periods. The frequency of observing
sessions required to determine the position and other
parameters of a pulsar is dependent on the initial accuracy
of the coordinates. For this reason, we decided to obtair an updated position for PSR1854+00 before analysing timing and modulation in the coordinates of the pursar courd produce and
annual modulation in the arrival time with an amplitude
of a few pulse periods. The frequency of observing
sessions required to determine the position and o derivative (P) and celestial coordinates.

Although the tracking capability of the ORT is well suited to timing measurements of pulsar, the logistics of scheduling frequent observing sessions on a given weak pulsar made it difficult to determine the parameters of measurements taken to determine the period (P), period
derivative (P) and celestial coordinates.
Although the tracking capability of the ORT is well
suited to timing measurements of pulsar, the logistics of
scheduling freq system did not have the narrow-band filters needed to obtain suited to timing measurements of pulsar, the logistics of scheduling frequent observing sessions on a given weak
pulsar made it difficult to determine the parameters of
PSR1854+00 from Ooty data alone. In addition, the ORT Hence, observations were requested with the Effelsberg 100-m telescope to obtain improved parameters for PSR1854+00. PSR1854+00 from Ooty data alone. In addition, the ORT
system did not have the narrow-band filters needed to obtain
an accurate estimate of the pulsar dispersion measure.
Hence, observations were requested with the Effelsbe D.A.Graham and J.H. Seiradakis. between the particle of the particle and the Effelsberg 100-m
cope to obtain improved parameters for PSR1854+00.
were made in 1983 at a frequency of 1420 MHz by
raham and J.H. Seiradakis.
The Effelsberg observations gave Hence, observations were requested with the Effelsberg 100-n
telescope to obtain improved parameters for PSR1854+00.
These were made in 1983 at a frequency of 1420 MHz by
D.A.Graham and J.H. Seiradakis.
The Effelsberg obse

pulsar of RA=18^h54^m28^S±15^S,DEC=00⁰53'50"±60", DM=90±5 cm⁻³

0.5 mJy, compared with the Ooty value of 15 mJy at 327 MHz,
yielding a spectral index α of 2.2 (S $\alpha \nu^{-\alpha}$). Such a value and the sample of 15 mJy at 327 MHz,
yielding a spectral index a of 2.2 (S a $\nu^{-\alpha}$). Such a value
is typical for a pulsar (Hewish, 1982). is typical for a pulsar (Newish, 1982). Jy, compared with the Ooty value of 15 mJy at 327 MHz,
ing a spectral index α of 2.2 ($S \propto \nu^{-\alpha}$). Such a value
pical for a pulsar (Hewish, 1982).
Observations with the Ooty Radio Telescope
Timing data were obtained

6.1.1 Observations with the Ooty Radio Telescope

yielding a spectral index α of 2.2 ($S \propto \nu^{-\alpha}$). Such a value
is typical for a pulsar (Hewish, 1982).
6.1.1 Observations with the Ooty Radio Telescope
Timing data were obtained at Ooty over a period of one
year. The b.5 mby, compared with the oot
yielding a spectral index α of
is typical for a pulsar (Hewis
6.1.1 Observations with the O
Timing data were obtained
year. The intitial observing
derivative (P) of 10^{-15} ss⁻¹
accumul value of 15 may at 327 mm2,
2 ($S \propto \nu^{-\alpha}$). Such a value
1982).
y Radio Telescope
t Ooty over a period of one
ssions indicated a period
(Mohanty 1983) and the
p observing sessions due to accumulated residuals between two observing sessions due to 6.1.1 Observations with the Ooty Radio Telescope
Timing data were obtained at Ooty over a period of one
year. The intitial observing sessions indicated a period
derivative (P) of 10^{-15} ss⁻¹ (Mohanty 1983) and the
accu 6.1.1 Observations with the Ooty Radio Telescope

Timing data were obtained at Ooty over a period of one

year. The intitial observing sessions indicated a period

derivative (P) of 10^{-15} ss⁻¹ (Mohanty 1983) and the
 Timing data were obtained at Ooty over a period of one
year. The intitial observing sessions indicated a period
derivative (\dot{P}) of 10^{-15} ss⁻¹ (Mohanty 1983) and the
accumulated residuals between two observing sessi derivative (P) of 10⁻¹⁵ss⁻¹ (Mohanty 1983) and the
accumulated residuals between two observing sessions due to
the slowing down of the pulsar were expected to be small.
Following the arrival of improved parameters from derivative (P) of 10⁻¹⁵ss⁻¹ (Mohanty 1983) and the
accumulated residuals between two observing sessions due to
the slowing down of the pulsar were expected to be small.
Following the arrival of improved parameters from the slowing down of the pulsar were expected to be small.
Following the arrival of improved parameters from
Effelsberg, a simple procedure was used to derive improved
pulsar coordinates from the pulse arrival times obtaine corresponding arrival times at the barycentre were computed. Effelsberg, a simple procedure was used to derive improved
pulsar coordinates from the pulse arrival times obtained
over a limited number of observing sessions. Firstly, the
Effelsberg position was adopted for the pulsar a pulsar coordinates from the pulse arrival times obtained
over a limited number of observing sessions. Firstly, the
Effelsberg position was adopted for the pulsar and the
corresponding arrival times at the barycentre were c pulsar coordinates from the pulse arrival times obtained
over a limited number of observing sessions. Firstly, the
Effelsberg position was adopted for the pulsar and the
corresponding arrival times at the barycentre were c position soor annuove from one pured arrival somes observing
over a limited number of observing sessions. Firstly, the
effelsberg position was adopted for the pulsar and the
corresponding arrival times at the barycentre we corresponding arrival times at the barycentre were computed.
A least-squares fit was made to obtain P, P and the chi-
squared value of the fit. The coordinates were optimised to
minimise chi-square and give an improved pos followed to estimate P and P using all the available data. position was then used as the new initial value to analyse
data spread over a longer time interval. This procedure was
followed to estimate P and P using all the available data.
The residuals, the differences between the a minimise chi-square and give an improved position. This
position was then used as the new initial value to analyse
data spread over a longer time interval. This procedure was
followed to estimate P and P using all the avai minimise chi-square and give an improved position. This
position was then used as the new initial value to analys
data spread over a longer time interval. This procedure wa
followed to estimate P and P using all the availa data spread over a longer time interval. This procedure was
followed to estimate P and P using all the available data.
The residuals, the differences between the arrival times of
the pulses and those expected from the leas portion and shen dood as the Hew Hirdar variation committed and detainable data.
Followed to estimate P and P using all the available data.
The residuals, the differences between the arrival times of
the pulses and those e systematics which can be seen in the residuals had values of

Fig. 6.1. The plots (A) and (B) are the timing residuals for PSRs 1854+00 and 2045-16 computed from observations with ORT. Observations were not done during the intervals indicated by discontinuities in these lines.

Page 114

11
less than 10 msec, these are likely to be uncertainties in
the clock calibration. The parameters obtained for PSR 11!
less than 10 msec, these are likely to be uncertainties in
the clock calibration. The parameters obtained for PSR
2045-16 (Table 6.1) were checked against the tabulated
values (Manchester and Taylor 1981) and found to ¹¹

2045-16 (Table 6.1) were checked against the clock calibration. The parameters obtained for PSF

2045-16 (Table 6.1) were checked against the tabulated

values (Manchester and Taylor, 1981) and found to be in 11
11
the clock calibration. The parameters obtained for PSF
2045-16 (Table 6.1) were checked against the tabulated
values (Manchester and Taylor, 1981) and found to be in
excellent agreement with these. The coordinates, t excellent agreement with these. The coordinates, the period and its time derivative, and the dispersion measure of less than 10 msec, these are likely to be uncertainties in
the clock calibration. The parameters obtained for PSR
2045-16 (Table 6.1) were checked against the tabulated
values (Manchester and Taylor, 1981) and found to be 2045-16 (Table 6.1) were checked against the tabulated
values (Manchester and Taylor, 1981) and found to be in
excellent agreement with these. The coordinates, the period
and its time derivative, and the dispersion measur the clock calibration. The parameters $(2045-16 \text{ (Table 6.1})$ were checked against
values (Manchester and Taylor, 1981) and
excellent agreement with these. The coord
and its time derivative, and the disper
PSR1854+00 are pre The tabulated

the tabulated

the period

measure of

note that

is 9.6x10¹⁰G

all pulsars PSR1854+00 are presented in Table 6.2. We note that
the derived magnetic field for PSR1854+00 is 9.6×10^{10} G
compared to a median of 1.2×10^{12} G for all pulsars
(Manchester and Taylor, 1981).

6.2 THE DISTANCE TO PSR1854+00

The distance to a pulsar is estimated by dividing its dispersion measure by the most probable value of the average electron density along the line of sight to the pulsar. Two 6.2 THE DISTANCE TO PSR1854+00
The distance to a pulsar is estimated by dividing its
dispersion measure by the most probable value of the average
electron density along the line of sight to the pulsar. Two
approaches are i 6.2 THE DISTANCE TO PSR1854+00
The distance to a pulsar is estimated by dividing its
dispersion measure by the most probable value of the average
electron density along the line of sight to the pulsar. Two
approaches are i of 0.03 cm^{-3} , has been derived using the distances to about two dozen pulsars obtained from HI-absorption measurements, together with their dispersion measures (Manchester and Taylor, 1977). The expression used to derive the second value of the electron density depends on the z-height and of 0.03 cm⁻³, has been derived using the distances to about
two dozen pulsars obtained from HI-absorption measurements,
together with their dispersion measures (Manchester and
Taylor, 1977). The expression used to deriv of 0.03 cm⁻³, has been derived using the distances to about
two dozen pulsars obtained from HI-absorption measurements,
together with their dispersion measures (Manchester and
Taylor, 1977). The expression used to derive two dozen pulsars obtained from HI-absorption measurements,
together with their dispersion measures (Manchester and
Taylor, 1977). The expression used to derive the second
value of the electron density depends on the z-hei

Table 6.1

Table 6.2

Parameters of PSR1854+00

Note : w_{50} is the half width $% w_{\mu }$ and B the derived magnetic field.

evidence has been accumulating that these methods can often be poor indicators of distance. For example, the measured DM for PSR0833-45 of 69 cm^{-3} pc is not consistent with the 11:
evidence has been accumulating that these methods can often
be poor indicators of distance. For example, the measured
DM for PSR0833-45 of 69 cm⁻³ pc is not consistent with the
expected distance of 500 pc, assuming t 11
evidence has been accumulating that these methods can ofter
be poor indicators of distance. For example, the measurec
DM for PSR0833-45 of 69 cm⁻³ pc is not consistent with the
expected distance of 500 pc, assuming th broadening suffered by pulses from a pulsar at any radio be poor indicators of distance. For example, the measured
DM for PSR0833-45 of 69 cm⁻³ pc is not consistent with the
expected distance of 500 pc, assuming the pulsar to be
associated with the Vela SNR. Further, the scatt the pulsar, indicated by its DM (Manchester and Taylor, DM for PSR0833-45 of 69 cm⁻³ pc is not consistent with the
expected distance of 500 pc, assuming the pulsar to be
associated with the Vela SNR. Further, the scattering
proadening suffered by pulses from a pulsar at any r expected distance of 500 pc, assuming the pulsar to be
associated with the Vela SNR. Further, the scattering
broadening suffered by pulses from a pulsar at any radio
frequency is expected to be a function of the distance t the pulsar, indicated by its DM (Manchester and Taylor,
1977). Although the measured scatter broadening for most
pulsars indicates a dependence on DM, there are pulsars
which do not follow the trend. For example, the pulse associated with the Vela SNR. Furth
broadening suffered by pulses from
frequency is expected to be a funct
the pulsar, indicated by its DM (Ma
1977). Although the measured scatter
pulsars indicates a dependence on DM
which wlsar at any radio
of the distance to
ester and Taylor,
badening for most
there are pulsars
le, the pulses from
large scattering
from PSR1338-62, the pulsar, indicated by its DM (Manchester and Taylor, 1977). Although the measured scatter broadening for most
pulsars indicates a dependence on DM, there are pulsars
which do not follow the trend. For example, the puls frequency (Manchestor, D'Amico, and Tupic),
pulsars indicates a dependence on DM, there are pulsars
which do not follow the trend. For example, the pulses from
PSR1758-23 with DM-1140 cm⁻³ pc show large scattering
broad points to large variations in the electron distribution which do not follow the trend. For example, the pulses from
PSR1758-23 with DM=1140 cm⁻³ pc show large scattering
broadening even at 1420 MHz, while those from PSR1338-62,
with a DM of 880 cm⁻³pc show little broadening shown (Krishnamohan, 1986) that there ere is the state of the producering
broadening even at 1420 MHz, while those from PSR1338-62,
with a DM of 880 cm⁻³pc show little broadening at this
frequency (Manchestor, D'Amico, a with a DM of 880 cm⁻³pc show little broadening at this
frequency (Manchestor, D'Amico, and Tuohy, 1985). This
points to large variations in the electron distribution
for different directions in the Galaxy. It has also be have low electron densities. only (manchester, b Amreo, and ruon), 1585). This
s to large variations in the Galaxy. It has also been
(Krishnamohan, 1986) that there are regions in the
tic plane with dimensions of hundreds of parsec that
low electron d for different directions in the Galaxy. It has also been
shown (Krishnamohan, 1986) that there are regions in the
galactic plane with dimensions of hundreds of parsec that
have low electron densities.
Thus, while the assum

distances estimated in individual cases should be considered have low electron densities.

Thus, while the assumed electron density can give

statistical distribution of the pulsars in the Galaxy, the

distances estimated in individual cases should be considered

with due reservatio Thus, while the assumed electron density can give
Thus, while the assumed electron density can give
the statistical distribution of the pulsars in the Galaxy, the
distances estimated in individual cases should be considere Thus, while the assumed electron density can give the
statistical distribution of the pulsars in the Galaxy, the
distances estimated in individual cases should be considered
with due reservation. With this in mind, the di Thus, while the assumed electron density can give
statistical distribution of the pulsars in the Galaxy, the
distances estimated in individual cases should be considered
with due reservation. With this in mind, the distan

6.3 AN HI SHELL AROUND THE SNR W44

11

AN HI SHELL AROUND THE SNR W44

Observations of the 21-cm hyperfine line of HI have

that the SNR W44 coincides with a cold HI shell

ding at a yelocity of about 4 kms⁻¹ (Knapp & Kern Taylor (1985).
 6.3 AN HI SHELL AROUND THE SNR W44

Observations of the 21-cm hyperfine line of HI have

shown that the SNR W44 coincides with a cold HI shell

expanding at a velocity of about 4 kms⁻¹ (Knapp & Kerr, Taylor (1985).

6.3 AN HI SHELL AROUND THE SNR W44

Observations of the 21-cm hyperfine line of HI have

shown that the SNR W44 coincides with a cold HI shell

expanding at a velocity of about 4 kms⁻¹ (Knapp & Kerr,

197 1974). For the kinematic distance of 3 kpc, a diameter of 80 pc $\,$ for the shell puts its age at 6x10 6 yr. Observations of the 21-cm hyperfine line of HI have
shown that the SNR W44 coincides with a cold HI shell
expanding at a velocity of about 4 kms⁻¹ (Knapp & Kerr,
1974). For the kinematic distance of 3 kpc, a diameter of

There is also an infra-red source, W44-IRS1, situated Wynn-Williams, Biechman and Downes, 1981). Although outside 1974). For the kinematic distance of 3 kpc, a diameter of
80 pc for the shell puts its age at $6x10^6$ yr.
There is also an infra-red source, W44-IRS1, situated
about 6' beyond the edge of W44 (Fig.6.2) (Wootten, 1978;
Wy Wootten (1978) suggested that W44-IRS1 might be a case of the SNR, this source is within the expanding HI shell.
Wootten (1978) suggested that W44-IRS1 might be a case of
SN-induced star formation, triggered by the SN of W44. Wynn-Williams, Biechman and Downes (1981) considered this to be unlikely because of its physical separation from the SNR and the well-developed stage of the HII region. However, if the expanding HI shell were considered to be the signature of an earlier SN explosion close to the site of SNR W44 about 10^7 yr ago, the question of whether the formation of W44-IRS1 unlikely because of its physical separation from the SNR and
the well-developed stage of the HII region. However, if the
expanding HI shell were considered to be the signature of an
earlier SN explosion close to the site consideration. or SN explosion close to the site of SNR W44 about 10⁷
o, the question of whether the formation of W44-IRS1
influenced by this earlier SN explosion needs due
deration.
THE AGE OF PSR 1854+00
In terms of a possible connec

6.4 THE AGE OF PSR 1854+00

and W44, it is important to estimate an age for the pulsar. The age of a possible connection between psections provided and W44, it is important to estimate an age for the pulsar.
The age of a pulsar can be estimated from its P and P, under

Page 120

Fig. 6.2. The W44 region.

Distribution of objects in the W44 region. Solid contours show the HI shell (Knapp and Kerr, 1974). SNR W44 is shown hatched, the positions of PSRs 1854+00 and 1853+01 are indicated by P and Q respectively, * denotes the infrared source IRS1.

assumptions regarding its initial period and the form of
decay of its magnetic field. While the estimated age of a decay of its magnetic field. While the estimated age of a 12
assumptions regarding its initial period and the form of
decay of its magnetic field. While the estimated age of a
short-period pulsar could also be in error due to the
cumulative contribution of glitches, the major sou 12
assumptions regarding its initial period and the form of
decay of its magnetic field. While the estimated age of a
short-period pulsar could also be in error due to the
cumulative contribution of glitches, the major sou 12
assumptions regarding its initial period and the form of
decay of its magnetic field. While the estimated age of a
short-period pulsar could also be in error due to the
cumulative contribution of glitches, the major sou 12
assumptions regarding its initial period and the form of
decay of its magnetic field. While the estimated age of a
short-period pulsar could also be in error due to the
cumulative contribution of glitches, the major sou generally believed to be born with periods shorter than a decay of its magnetic field. While the estimated age of a
short-period pulsar could also be in error due to the
cumulative contribution of glitches, the major source of
error for a long-period pulsar originates in the assu cumulative contribution of glitches, the major source of
error for a long-period pulsar originates in the assumed
time scale of decay of its magnetic field. Pulsars are
generally believed to be born with periods shorter th short-period puisar could also be in error due to the
cumulative contribution of glitches, the major source of
error for a long-period pulsar originates in the assumed
time scale of decay of its magnetic field. Pulsars are error for a long-period pulsar originates in the assumed
time scale of decay of its magnetic field. Pulsars are
generally believed to be born with periods shorter than a
few tens of msec. However, the age estimate could be erior for a fong-period paigar originates in the assumed
time scale of decay of its magnetic field. Pulsars are
generally believed to be born with periods shorter than
few tens of msec. However, the age estimate could be i generally believed to be born with periods shorter than a
few tens of msec. However, the age estimate could be in
serious error for a long-period pulsar such as PSR1854+00
if it were born with a period close to its present Few tens of msec. However, the age estimate could be in
serious error for a long-period pulsar such as PSR1854+00
if it were born with a period close to its present
value. Pulsars, in principle, slow down because of
gravit dif it were born with a period close to its present
value. Pulsars, in principle, slow down because of
gravitational and magnetic braking (Ostriker and Gunn,
1969). For pulsars of period >100 msec., the braking
produced by serious error for a fong period parsar such as ronfoot-foot
if it were born with a period close to its present
value. Pulsars, in principle, slow down because of
gravitational and magnetic braking (Ostriker and Gunn,
1969 $\mathbf{\hat{c}}$ =K. $\mathbf{\Omega}^\mathbf{n}$ For value. Pulsars, in principle, slow down because
gravitational and magnetic braking (Ostriker and
1969). For pulsars of period >100 msec., the l
produced by the radiation from the rotating m
dipole plays the dominant role. 1969). For pulsars of period >100 msec., the braking
produced by the radiation from the rotating magnetic
dipole plays the dominant role. This braking torque is
such that the resultant slowing down is proportional to
a po 1969). For pulsars of period >100 msec., the braking
produced by the radiation from the rotating magnetic
dipole plays the dominant role. This braking torque is
such that the resultant slowing down is proportional to
a po the moment of inertia of the neutron star. Integrating such that the resultant slowing down is proportional to
a power of the rotation frequency, i.e., $\dot{\Omega} = K.\Omega^n$ For
dipole braking, n=3 and the constant K is proportional
to the ratio of the square of the magnetic moment an such that the resultant slowing down is proportional
a power of the rotation frequency, i.e., $\hat{\Omega} = K.\Omega^n$ For
dipole braking, n=3 and the constant K is proportional
to the ratio of the square of the magnetic moment and
t 1977). =3 and the square
tia of
tia of
on, the fr
by the exp
= $\frac{\Omega}{(n-1)\hat{\Omega}}$
lsation fr square of
ia of the
, the freque
the express
 $\frac{\Omega}{(n-1)\hat{\Omega}}\left[1 - \frac{\Pi}{n}\right]$
ation freque

$$
t = \frac{\Omega}{(n-1)\dot{\Omega}} \left[1 - \left(\frac{\Omega}{\Omega_i} \right)^{n-1} \right]
$$
 (6.3)

where Ω_i is the pulsation frequency at t=0 and the term K has been assumed to be constant with time. For $\Omega \ll \Omega_i$ the characteristic age τ is given by

$$
\tau = \frac{\Omega}{(n-1)\hat{\Omega}} = \frac{p}{(n-1)\hat{P}} \dots (n \times 1) \qquad (6.4)
$$

from a rotating magnetic dipole,

$$
n = 3 \text{ and } \tau = P/2\hat{P}.
$$

For radiation from a rotating magnetic dipole,

$$
n = 3
$$
 and $\tau = P/2P$.

The above expression represents the age of the pulsar 122
 $\tau = \frac{\Omega}{(n-1)\Omega} = \frac{p}{(n-1)p}$...(n*1) (6.4)

For radiation from a rotating magnetic dipole,
 $n = 3$ and $\tau = P/2p$.

The above expression represents the age of the pulsar

assuming that $\Omega \ll \Omega_1$ and that the pulsar For radiation from a rotating magnetic dipole,
 $n = 3$ and $\tau = P/2P$.

The above expression represents the age of the pulsar

assuming that $\Omega \ll \Omega_1$ and that the pulsar magnetic field has

remained constant. The conclus fields decay as the object ages has been arrived at from For radiation from a rotating magnetic dipole,
 $n = 3$ and $\tau = P/2P$.

The above expression represents the age of the pulsar

assuming that $\Omega \ll \Omega_1$ and that the pulsar magnetic field has

remained constant. The conclus The above expression represents the age of the pulsar
assuming that $\Omega \ll \Omega_{\rm i}$ and that the pulsar magnetic field has
remained constant. The conclusion that pulsar magnetic
fields decay as the object ages has been arri pulsars with high values of z. The time scale for the decay of pulsar magnetic fields has been estimated to be in the range of 2 to 20x10⁶ eriod distribution and the deficit of
lues of z. The time scale for the decay
ields has been estimated to be in the
yr (Radhakrishnan, 1982; Krishnamohan,
exponentially-decaying magnetic field, 1987). Assuming an exponentially-decaying magnetic field, pulsars with high values of z. The time scale for the decay
of pulsar magnetic fields has been estimated to be in the
range of 2 to 20x10⁶ yr (Radhakrishnan, 1982; Krishnamohan,
1987). Assuming an exponentially-decaying riod distribution and the deficit of
ues of z. The time scale for the decay
elds has been estimated to be in the
yr (Radhakrishnan, 1982; Krishnamohan,
xponentially-decaying magnetic field,
t, is given by (Gunn & Ostriker

$$
t = \frac{t_d}{2} \ln (1 + \tau / t_d)
$$
 (6.3)

where t_d is the time scale of decay and τ is the characterstic age.

ge of a pulsar, t, is given by (Gunn & Ostriker, 1970):
 $t = \frac{t_d}{2} \ln (1+r/t_d)$ (6.3)

where t_d is the time scale of decay and τ is the

cterstic age.

Although the time scale for magnetic-field decay is

able, the age the age or a pursar, t, is given by (dunn a Ostriker, 1970):
 $t = \frac{t_d}{2} \ln (1+r/t_d)$ (6.3)

where t_d is the time scale of decay and τ is the

characterstic age.

Although the time scale for magnetic-field decay is

deb 10x10^b yr, assuming <mark>a time scale for magnetic field decay</mark> of 9x10^b yr (Lyne, Manchester and Taylor, 1985). This estimate is not affected by the mode of injection of the pulsar, provided that the underlying assumptions that a neutron star is born with a short period, and that the decay of the

magnetic field can be described by a single time scale during most of its life, are valid.

6.5 THE SNR W44

6.5.1 The Radio Remnant

tic field can be described by a single time scale
g most of its life, are valid.
THE SNR W44
The Radio Remnant
The SNR W44 has been classified as being of shell type
e radio region. Its age has been estimated to be about
y in the radio region. Its age has been estimated to be about 3900 yr using the Z-t relation for SNRs of Clark
3900 yr using the Z-t relation for SNRs of Clark and
3900 yr using the Z-t relation for SNRs of Clark and
3900 yr using the Z-t relation for SNRs of Clark and
3900 yr using The SNR W44 has been classified as being of shell typ
in the radio region. Its age has been estimated to be about
3900 yr using the Σ -t relation for SNRs of Clark and
Caswell (1976). It is one of the few SNRs for which estimates are available from HI and OH-absorption studies. The SNR W44 has been classified as being of shell typ
in the radio region. Its age has been estimated to be about
3900 yr using the Σ -t relation for SNRs of Clark and
Caswell (1976). It is one of the few SNRs for which The SNR W44 has been classified as being of shell typ
in the radio region. Its age has been estimated to be about
3900 yr using the Σ -t relation for SNRs of Clark and
Caswell (1976). It is one of the few SNRs for which contours indicating the likely interaction of the SNR with a neighbouring molecular cloud (Wootten, 1977).

6.5.2 The X-ray Remnant and its Mass

W44 has been studied using the Imaging Proportional Inc. Costmaced arouance of order hype is constanted to be
sound (Green 1989). The SNR has a pear-shaped shell with
contours indicating the likely interaction of the SNR with a
neighbouring molecular cloud (Wootten, 1977).
 eound (died. 1989). The onk has a pear onaped one it with a
contours indicating the likely interaction of the SNR with a
neighbouring molecular cloud (Wootten, 1977).
6.5.2 The X-ray Remnant and its Mass
W44 has been studi 6.5.2 The X-ray Remnant and its Mass
W44 has been studied using the Imaging Proportional
Counter (IPC) aboard the Einstein Observatory (Watson
etal., 1983). Unlike most SNRs, the X-rays originate from
the central volume of from the surrounding shell. This makes W44 a member of a W44 has been studied using the Imaging Proportional
Counter (IPC) aboard the Einstein Observatory (Watson
etal., 1983). Unlike most SNRs, the X-rays originate from
the central volume of the remnant and no emission is seen
 detail in Chapter 7. the central volume of the remnant and no emission is seen
from the surrounding shell. This makes W44 a member of a
separate class of SNRs which will be dealt with in some
detail in Chapter 7.
The mass of the X-ray emitting

The mass of the X-ray emitting material within this SNR separate class of SNRs which will be dealt with in some
detail in Chapter 7.
The mass of the X-ray emitting material within this SNR
has been calculated to be 60 M_O (Watson etal., 1983). In
order to compute this mass, it

radiation is entirely of thermal origin and that the filling 12

radiation is entirely of thermal origin and that the filling

factor is unity. However, if most of the observed X-ray

radiation originates from non-thermal emission, then the radiation is entirely of thermal origin and that the filling
factor is unity. However, if most of the observed X-ray
radiation originates from non-thermal emission, then the
above mass could be a considerable overestimate. 12

andiation is entirely of thermal origin and that the filling

factor is unity. However, if most of the observed X-ray

radiation originates from non-thermal emission, then the

above mass could be a considerable overes 12

radiation is entirely of thermal origin and that the filling

factor is unity. However, if most of the observed X-ray

radiation originates from non-thermal emission, then the

above mass could be a considerable overes radiation originates from non-thermal emission, then the
above mass could be a considerable overestimate. The only
method of resolving this question is to obtain. high
resolution X-ray spectroscopy of the SNR. In the absen factor is unity. However, if most of the observed X-ray
radiation originates from non-thermal emission, then the
above mass could be a considerable overestimate. The only
method of resolving this question is to obtain. hig material is several tens of solar mass. d of resolving this question is to obtain. high
ution X-ray spectroscopy of the SNR. In the absence of
we will assume that the mass of the X-ray emitting
ial is several tens of solar mass.
We can consider possible origins method of resolving this question is to obtain. high
resolution X-ray spectroscopy of the SNR. In the absence of
this, we will assume that the mass of the X-ray emitting
material is several tens of solar mass.
We can consi

this, we will assume that the mass of the X-ray emitting
material is several tens of solar mass.
We can consider possible origins for such a large mass
within the central volume of the SNR. For example,
considering that W4 We can consider possible origins for such a large mass
within the central volume of the SNR. For example,
considering that W44 is in the neighbourhood of a dense
molecular cloud (Wootten, 1977), it is likely that most of
t material is several tens of solar mass.
We can consider possible origins for such a large mass
within the central volume of the SNR. For example,
considering that W44 is in the neighbourhood of a dense
molecular cloud (Woo interstellar medium expected in the neighbourhoods of such a within the central volume of the SNR. For example,
considering that W44 is in the neighbourhood of a dense
molecular cloud (Wootten, 1977), it is likely that most of
the X-ray emitting material originated in the dense
inte would be responsible for the peculiar X-ray morphology of example,
considering that W44 is in the neighbourhood of a dense
molecular cloud (Wootten, 1977), it is likely that most of
the X-ray emitting material originated in the dense
interstellar medium expected in the neighbourh molecular cloud (Wootten, 1977), it is likely that most of
the X-ray emitting material originated in the dense
interstellar medium expected in the neighbourhoods of such a
cloud. In this case, the differential rate of cool interstellar medium expected in the neighbourhoods of such a
cloud. In this case, the differential rate of cooling
would be responsible for the peculiar X-ray morphology of
the SNR. Although this is plausible, it is intrig of the interstellar medium expected in the neighbourhoods of such a
cloud. In this case, the differential rate of cooling
would be responsible for the peculiar X-ray morphology of
the SNR. Although this is plausible, it is within the present volume of the SNR into its shell. The freezing of the ionised cloud material to this field would also have resulted in its incorporation into the shell. It is more probable that the X-ray emitting material originated in the progenitor star of the supernova. We will return to the question of the mass of the progenitor in Chapter 7.

6.6 A POSSIBLE ASSOCIATION BETWEEN PSR 1854+00 AND SNR W44

A POSSIBLE ASSOCIATION BETWEEN PSR 1854+00 AND SNR W
PSR1854+00 lies just outside the shell of W44
6.2). The projected separation from the centre of t (Fig.6.2). The projected separation from the centre of the 12

6.6 A POSSIBLE ASSOCIATION BETWEEN PSR 1854+00 AND SNR W44

PSR1854+00 lies just outside the shell of W44

(Fig.6.2). The projected separation from the centre of the

remnant is 30 pc for a distance of 3 kpc. Were it t the age of the SNR $(4x10^3$ yr, Clark and Caswell, 1976) 12!

ION BETWEEN PSR 1854+00 AND SNR W44

st outside the shell of W44

separation from the centre of the

stance of 3 kpc. Were it to have

yr, Clark and Caswell, 1976) it

nsverse velocity of 10⁴kms⁻¹ to

enaration would need to have a transverse velocity of 10^4 kms $^{-1}$ to account for the present separation.

Pulsars with such high velocities are not known and even the case of PSR2224+65, which has a reported velocity would need to have a transverse velocity of 10^4 kms⁻¹ to
account for the present separation.
Pulsars with such high velocities are not known and
even the case of PSR2224+65, which has a reported velocity
of 1750 kms⁻ 1986) or possibly indicate that the distance used to compute Pulsars with such high velocities are not known and
even the case of PSR2224+65, which has a reported velocity
of 1750 kms⁻¹, could be due to poor sensitivity (Cordes,
1986) or possibly indicate that the distance used to be ruled out that pulsars with such high-velocity do exist, but are scarce in the local volume of the Galaxy because pulsars are born close to the plane and high-velocity 1986) or possibly indicate that the distance used to compute
its space velocity is an over estimate. However, it can not
be ruled out that pulsars with such high-velocity do exist,
but are scarce in the local volume of the neighbourhood. As high-velocity pulsars would represent its space velocity is an over estimate. However, it can not
be ruled out that pulsars with such high-velocity do exist,
but are scarce in the local volume of the Galaxy because
pulsars are born close to the plane and highbe ruled out that pulsars with such high-velocity do exist,
but are scarce in the local volume of the Galaxy because
pulsars are born close to the plane and high-velocity
pulsars are expected to have moved away from the lo but are scarce in the local volume of the Galaxy because
pulsars are born close to the plane and high-velocity
pulsars are expected to have moved away from the local
neighbourhood. As high-velocity pulsars would represent
 pulsars are born close to the plane and high-velocity
pulsars are expected to have moved away from the local
neighbourhood. As high-velocity pulsars would represent
only a tiny fraction of the total pulsar population, it
w neighbourhood. As high-velocity pulsars would represent
only a tiny fraction of the total pulsar population, it
would not be surprising if they are not represented in
the local neighbourhood. Theoretically, such high
veloc only a tiny fraction of the total pulsar population, it
would not be surprising if they are not represented in
the local neighbourhood. Theoretically, such high
velocities are not impossible. According to the model of
Harr for showing
and in the total pulsar population, it
would not be surprising if they are not represented in
the local neighbourhood. Theoretically, such high
velocities are not impossible. According to the model of
Harrison Harrison and Tademaru (1977), pulsars are accelerat
high velocity during the early part of their life
force of radiation reaction which they suggest i
the space velocity to a pulsar, is proportional to Ω
being the puls 5 . B², Ω being the pulsar angular velocity and B its magnetic field. However, if the of PSR1854+00 age were to be 10^4 yr, the low

measured P would imply that the initial period would have
been close to the present period and the initial magnetic 12
Been close to the present period and the initial magnetic
period and the initial magnetic
field would have been low. In this case, the force of 121
measured P would imply that the initial period would have
been close to the present period and the initial magnetic
field would have been low. In this case, the force of
radiation reaction would have been insufficient measured P would imply that the initial period would have
been close to the present period and the initial magnetic
field would have been low. In this case, the force of
radiation reaction would have been insufficient to i such a high velocity. a pured P would imply that the initial period would have
close to the present period and the initial magnetic
d would have been low. In this case, the force of
ation reaction would have been insufficient to impart
a high v been close to the present period and the initial magnetic
field would have been low. In this case, the force of
radiation reaction would have been insufficient to impart
such a high velocity.
A pulsar can also get a high v

radiation reaction would have been insufficient to impart
such a high velocity.
A pulsar can also get a high velocity at the epoch of
its birth from an asymmetric supernova explosion. This is
believed to be a plausible mec radiation reaction would have been insufficient to impart
such a high velocity.
A pulsar can also get a high velocity at the epoch of
its birth from an asymmetric supernova explosion. This is
believed to be a plausible mec A pulsar can also get a high velocity at the epoch of
its birth from an asymmetric supernova explosion. This is
believed to be a plausible mechanism for imparting high
velocities to pulsars (Shklovskii, 1970a). In addition A pulsar can also get a high velocity at the epoch of
its birth from an asymmetric supernova explosion. This is
believed to be a plausible mechanism for imparting high
velocities to pulsars (Shklovskii, 1970a). In addition believed to be a plausible mechanism for imparting high
velocities to pulsars (Shklovskii, 1970a). In addition, a
pulsar formed by a SN explosion in a binary system could
acquire high velocity (Gott, Gunn and Ostriker, 197 pulsar formed by a SN explosion in a binary system could
acquire high velocity (Gott, Gunn and Ostriker, 1970;
Radhakrishnan and Shukre, 1985), where the sling-shot effect
(Blaauw, 1961) is invoked. However, it would be di velocities to pulsars (Shklovskii, 1970a). In addition, a
pulsar formed by a SN explosion in a binary system could
acquire high velocity (Gott, Gunn and Ostriker, 1970;
Radhakrishnan and Shukre, 1985), where the sling-shot needed is to pulsars (Shklovskii, 1970a). In addition, a
pulsar formed by a SN explosion in a binary system could
acquire high velocity (Gott, Gunn and Ostriker, 1970;
Radhakrishnan and Shukre, 1985), where the sling-shot acquire high velocity (Gott, Gunn and Ostriker, 1970;
Radhakrishnan and Shukre, 1985), where the sling-shot effect
(Blaauw, 1961) is invoked. However, it would be difficult to
employ this mechanism to account for the high its orbital velocity in the presupernova binary system Radhakrishnan and Shukre, 1985), where the sling-shot effect
(Blaauw, 1961) is invoked. However, it would be difficult to
employ this mechanism to account for the high velocity
needed if PSR1854+00 and W44 were to be asso $10⁴$ kms⁻¹ would imply a P of 1.5x10⁻¹⁶ss⁻¹ due to the makrismian and shakre, 15887, where the similar shot errect
aauw, 1961) is invoked. However, it would be difficult to
loy this mechanism to account for the high velocity
ded if PSR1854+00 and W44 were to be associated as employ this mechanism to account for the high velocity
needed if PSR1854+00 and W44 were to be associated as \cdot it
would imply that the pulsar has a similar velocity now to
its orbital velocity in the presupernova binar larger than our measured value of P. One may be extended

would imply that the pulsar has a similar velocity now to

its orbital velocity in the presupernova binary system

(Blaauw, 1961). In addition, a transverse veloci needed if PSR1854+00 a
would imply that the p
its orbital velocity
(Blaauw, 1961). In a
10⁴ kms⁻¹ would imply
train-whistle effect
larger than our measu
if the hypothetical
orogenitors of PSR1854 The presupernova binary system
ion, a transverse velocity of
 \dot{P} of 1.5x10⁻¹⁶ss⁻¹ due to the
Shklovskii, 1970b), which is
value of \dot{P} . On the other hand,
binary system containing the
and SNR W44 was disrupted (Blaauw, 1961). In addition, a transverse velocity of 10^4 kms⁻¹ would imply a \dot{P} of 1.5×10^{-16} ss⁻¹ due to the train-whistle effect (Shklovskii, 1970b), which is larger than our measured value of \dot{P} . 10^4 kms⁻¹ would imply a \dot{P} of 1.5x10⁻¹⁶ss⁻¹ due to the
train-whistle effect (Shklovskii, 1970b), which is
larger than our measured value of \dot{P} . On the other hand,
if the hypothetical binary system conta tordada, 1991). In addition, a cransverse verocity of
 10^4 kms⁻¹ would imply a \dot{P} of 1.5x10⁻¹⁶ss⁻¹ due to the

train-whistle effect (Shklovskii, 1970b), which is

larger than our measured value of \dot{P} . O provident in the train-whistle effect (Shklovskii, 1970b), which is
larger than our measured value of P. On the other hand,
if the hypothetical binary system containing the
progenitors of PSR1854+00 and SNR W44 was disrupt larger than our measured value of \dot{P} . On the other hand,
if the hypothetical binary system containing the
progenitors of PSR1854+00 and SNR W44 was disrupted during
an earlier SN explosion associated with the formati

probability of such a low velocity after disruption of a 12
probability of such a low velocity after disruption of a
binary system is small. We conclude that it is unlikely
that PSR1854+00 could be associated with SNR W44. that PSR1854+00 could be associated with SNR W44.

Very recently, a pulsar PSR1853+01 has been discovered probability of such a low velocity after disruption of a
binary system is small. We conclude that it is unlikely
that PSR1854+00 could be associated with SNR W44.
Very recently, a pulsar PSR1853+01 has been discovered
with Very recently, a pulsar PSR1853+01 has been discovered
within the radio contours of W44 (Wolszczan etal., 1988).
It has a period of 0.2674 sec. and a DM of 98±8 cm⁻³pc. Its
distance as estimated from its DM is 3.3 kpc us that PSR1854+00 could be associated with SNR W44.
Very recently, a pulsar PSR1853+01 has been discovered
within the radio contours of W44 (Wolszczan etal., 1988).
It has a period of 0.2674 sec. and a DM of 9818 cm⁻³pc. value for the mean electron density of 0.03 cm^{-3} and 2.5 kpc Very recently, a pulsar PSR1853+01 has been discovered
within the radio contours of W44 (Wolszczan etal., 1988)
It has a period of 0.2674 sec. and a DM of 98±8 cm⁻³pc. Its
distance as estimated from its DM is 3.3 kpc us Very recently, a pulsar PSR1853+01 has been discovered
within the radio contours of W44 (Wolszczan etal., 1988).
It has a period of 0.2674 sec. and a DM of 98±8 cm⁻³pc. Its
distance as estimated from its DM is 3.3 kpc u It has a period of 0.2674 sec. and a DM of 98±8 cm⁻³pc. Its
distance as estimated from its DM is 3.3 kpc using a global
value for the mean electron density of 0.03 cm⁻³ and 2.5 kpc
using an electron density based on t age is needed to investigate this further. ance as estimated from its DM is 3.3 kpc using a global

He for the mean electron density of 0.03 cm⁻³ and 2.5 kpc

Hg an electron density based on the more rigorous model

Hg an electron density based on the more rigor me, Manchester & Taylor (1985). It is possible that
pulsar is associated with W44 and an estimate of its
s needed to investigate this further.
A POSSIBLE ASSOCIATION BETWEEN PSR 1854+00 AND THE H
SHELL NEAR W44
The distanc

6.7 SHELL NEAR W44

this puisar is associated with w44 and an estimate of its
age is needed to investigate this further.
6.7 A POSSIBLE ASSOCIATION BETWEEN PSR 1854+00 AND THE H
SHELL NEAR W44
The distance derived for PSR1854+00 from its DM i connection between an HI shell and the pulsar PSR0740-28 6.7 A POSSIBLE ASSOCIATION BETWEEN PSR 1854+00 AND THE H
SHELL NEAR W44
The distance derived for PSR1854+00 from its DM is
also consistent with that suggested for the HI shell. A
connection between an HI shell and the puls interest consider whether the HI shell in the direction of W44 might be associated with PSR1854+00. also consistent with that suggested for the HI shell. A
connection between an HI shell and the pulsar PSR0740-28
has been suggested by Stacy and Jackson (1982). It is of
interest consider whether the HI shell in the direct

Knapp and Kerr (1974) suggest an age of 10 $^{\prime}$ yr for $\:$ the connection between an HI shell and the pulsar PSR0740-28
has been suggested by Stacy and Jackson (1982). It is of
interest consider whether the HI shell in the direction of
W44 might be associated with PSR1854+00.
Knapp a interest consider whether the HI shell in the direction of
W44 might be associated with PSR1854+00.
Knapp and Kerr (1974) suggest an age of 10⁷ yr for the
expanding HI shell near W44. This age agrees with that
derived f W44 might be associated with PSR1854+00.

Knapp and Kerr (1974) suggest an age of 10⁷ yr for the

expanding HI shell near W44. This age agrees with that

derived for PSR1854+00 in Section 6.4. The angular

separation of Knapp and Kerr (1974) suggest an age of 10⁷ yr for the
expanding HI shell near W44. This age agrees with that
derived for PSR1854+00 in Section 6.4. The angular
separation of the pulsar from the likely centroid of the
H

kms $^{\mathrm{-1}}$ to have attained the present separation of 30 pc $\,$ from $km s^{-1}$ to have attained the present separat
the centroid of the HI shell in 10⁷
distance of 3 kpc (Knapp and Kerr, 1974). yr, assuming a kms⁻¹ to have attained the present separat
the centroid of the HI shell in 10⁷
distance of 3 kpc (Knapp and Kerr, 1974). 12

It has been suggested that the velocities of pulsars

It has been suggested that the velocities of pulsars

Correlated with their magnetic fields (Helfand and

The velocities of pulsars

Correlated with their magnetic

are correlated with their magnetic fields (Helfand and kms⁻¹ to have attained the present separation of 30 pc from
the centroid of the HI shell in 10⁷ yr, assuming a
distance of 3 kpc (Knapp and Kerr, 1974).
It has been suggested that the velocities of pulsars
are correla such as PSR1854+00 could have a low space velocity. In this the centroid of the HI shell in 10⁷ yr, assuming a
distance of 3 kpc (Knapp and Kerr, 1974).
It has been suggested that the velocities of pulsars
are correlated with their magnetic fields (Helfand and
Tademaru, 1977), im were to be found close to the site of its birth. It is thus It has been suggested that the velocities of pulsars
are correlated with their magnetic fields (Helfand and
Tademaru, 1977), implying that a low-magnetic-field pulsar
such as PSR1854+00 could have a low space velocity. In We will return to the question of a low velocity for this plausible that PSR1854+00 is associated with the HI shell.
We will return to the question of a low velocity for this
pulsar in Chapter 7.